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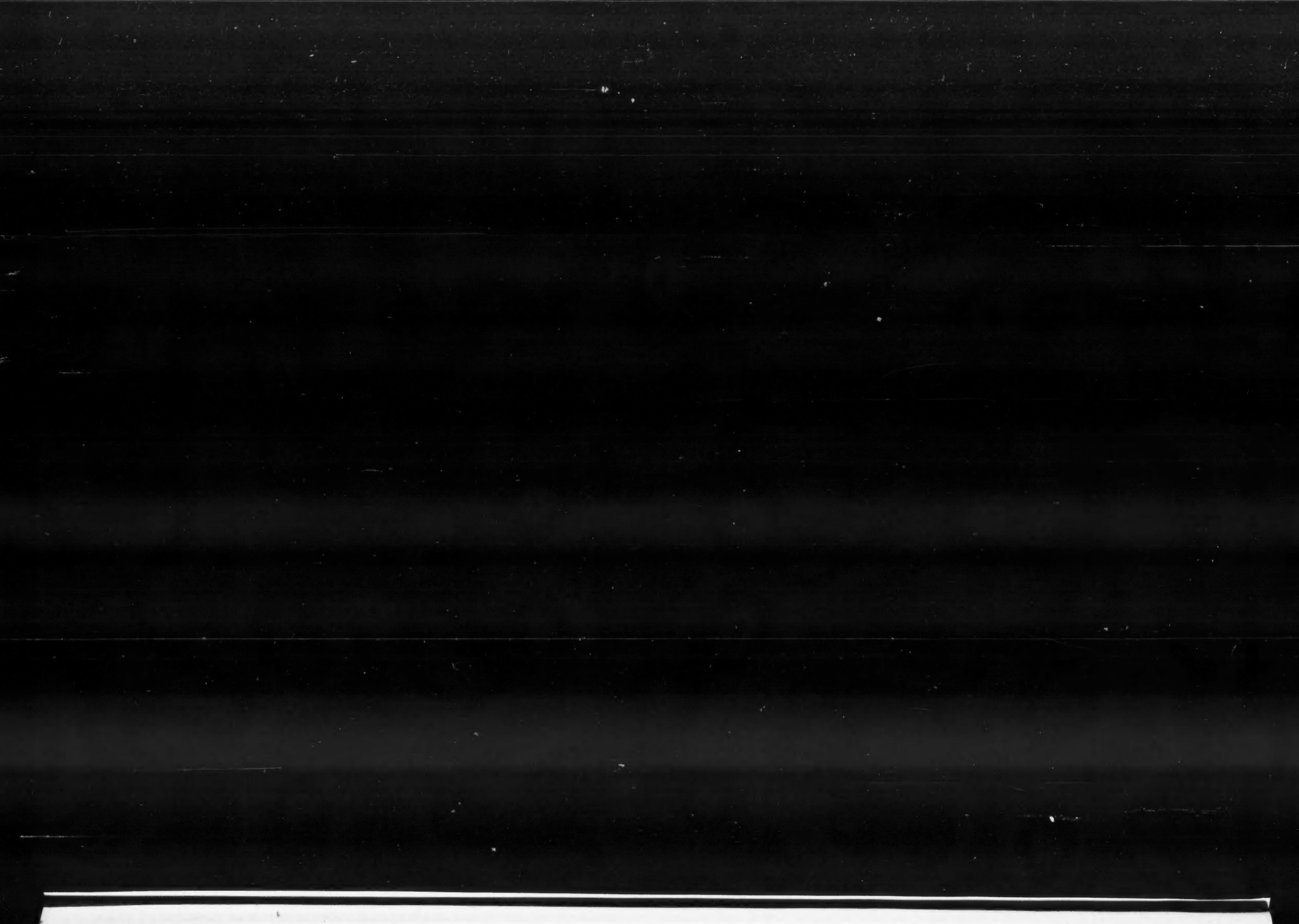


SOME LESSER-KNOWN TRACTION ENGINES.

By RONALD H. CLARK, A.M.I.Mech.E.

(*Concluded from page* 533.)

THE firm of Savages, Limited, St. Nicholas Works, King's Lynn, Norfolk, was founded by Frederick Savage in 1850 and is still in business. Savage's first engine was built in 1870. As was customary at that time, the cylinder was placed over the firebox, and the crankshaft was mounted in two bearings in a cast-iron bracket bolted to the barrel. A high-gear or a low-gear sprocket, whichever was in use, drove the counter-shaft by a chain, and the countershaft, incorporating a differential, drove each rear road wheel by means of a pinion engaging in an annular toothed ring, as in Dodman's engine, illustrated in Fig. 5, on page 530, *ante*. The low-gear sprocket was fixed to the crankshaft in line with the countershaft sprocket, and the high-gear sprocket was recessed to receive it and could slide along the crankshaft for this purpose, so that, when the high-gear pinion was in use, it was in line with the countershaft sprocket. The tension of the chain was adjusted by moving the jockey pulleys in the slotted frame. It was a tiresome job to change gear, therefore, and old drivers who remember these engines tell me that they did not trouble to change to high gear unless they were first assured of a long stretch of level running. The position of the steersman at the front of the engine was also a disadvantage, especially if he and the driver were not on good terms with each other. Three years later, in 1873, Savage brought out an improved engine, which is illustrated in Fig. 19, on this page. The steering was from the footplate through a worm and wheel to a chain barrel in front of the firebox, and this arrangement remained standard ever afterwards. The footplate was raised and the tender improved. In this form, the engine became widely used and well liked. At the same time, another design was introduced, incorporating one speed only, front steering, and cast-iron road wheels with six spokes, but it was inferior to the improved engine and only a few were built.

Savage's design of engine for ploughing and cultivating by steam is illustrated in Fig. 20. In this engine the cylinder was placed in the improved position at the smokebox end of the boiler, and the crankshaft drove the road wheels through three-shaft gearing. The wheels were cast with a deep groove in the centre of the tread, which was covered by a plate for travelling. The plate could be removed to reveal a coil of wire rope several hundred yards long, the ropes being coiled in opposite directions on the left-hand and right-hand wheels. To use the engine for ploughing or cultivating, it was placed in the middle of one side of the field. The rear end was jacked up until the wheels were clear of the ground, and the ropes taken round guide pulleys to each end of the cultivator or plough. As the work progressed, the pulleys were moved along the edge of the field. This system was quite practicable and several complete sets were sold in this country and exported to the Colonies. Savage's next design was the "Sandringham" class, a name suggested by the proximity of the Royal establishment. These engines became famous in east England and there are still some at work and in good condition. They had an ample reserve of boiler power and were equipped with Savage's patent slow-motion gear, which could be fitted in about 20 minutes and enhanced the ability of the engine to propel itself out of bad ground. Fig. 21 shows one of this class and Table VI, on page 555, gives details of the three different sizes that were made. They were built on the two-speed three-shaft principle, with the low-speed pinion next to the crankshaft bearing; the slow-motion gear introduced an extra-low reduction, or emergency third gear. Fig. 21 shows this arrangement, which is similar to the back-gear of a lathe. A stub axle placed between and slightly forward of the crankshaft and the second motion shaft carried a double pinion with 15 and 35 teeth. To engage the slow-motion gear, the high-speed and low-speed pinions on the crankshaft were slid along the shaft out of mesh with the gears on the second-motion shaft, the slow-motion double-pinion was placed on the stub axle so that the 35-tooth pinion engaged with the low-speed pinion on the crankshaft, and the 15-tooth pinion engaged with the large gear on the second-motion shaft. In this extra low gear the engine ran on a four-shaft layout, and the reduction from crankshaft to roadwheel was 56·65 to 1. The corresponding ratio for the normal low gear was 24·28 to 1, and for the high gear, 12·18 to 1. The workmanship and finish of these engines were of a high order, as Fig. 21 shows.

Of all the old engines with rare features, perhaps the most interesting is Savage's first showman's

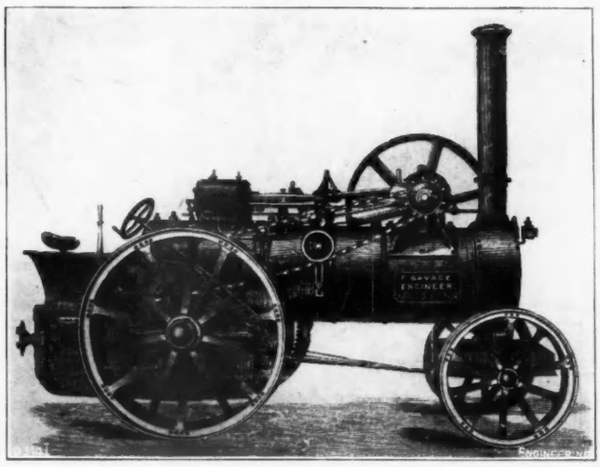


FIG. 19. SECOND TYPE OF CHAIN ENGINE, BY F. SAVAGE, (1873).

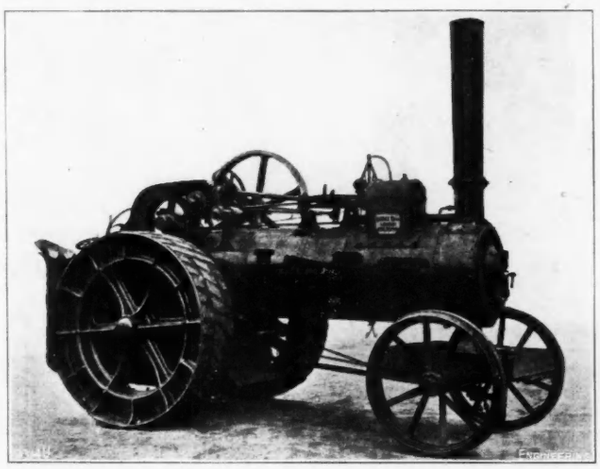


FIG. 20. PLOUGHING AND TRACTION ENGINE, BY F. SAVAGE.

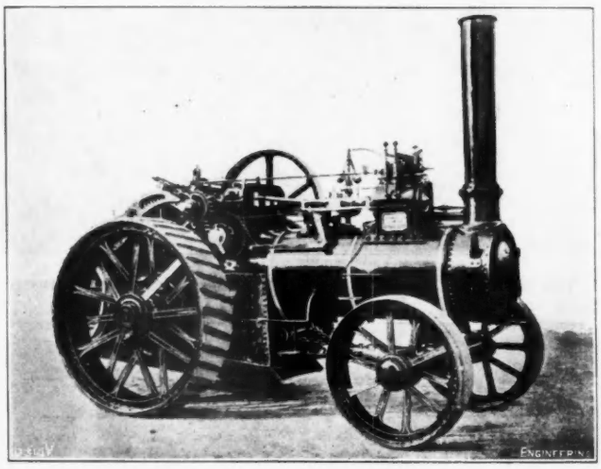


FIG. 21. "SANDRINGHAM" CLASS TRACTION ENGINE, BY F. SAVAGE.

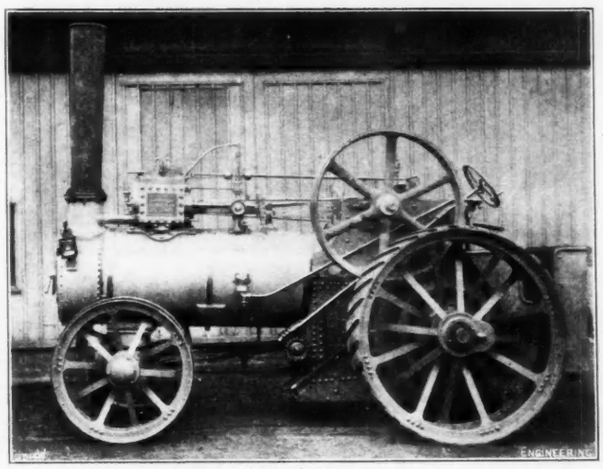


FIG. 22. SAVAGE'S SHOWMAN'S ENGINE, WITH ANNULAR COMPOUND CYLINDER.

SOME LESSER-KNOWN TRACTION ENGINES.

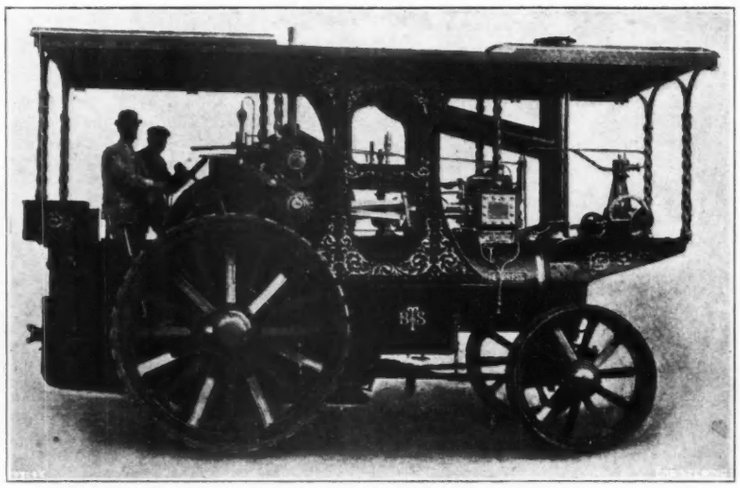


FIG. 23. FIRST SAVAGE DOUBLE-CRANK COMPOUND SHOWMAN'S ENGINE.

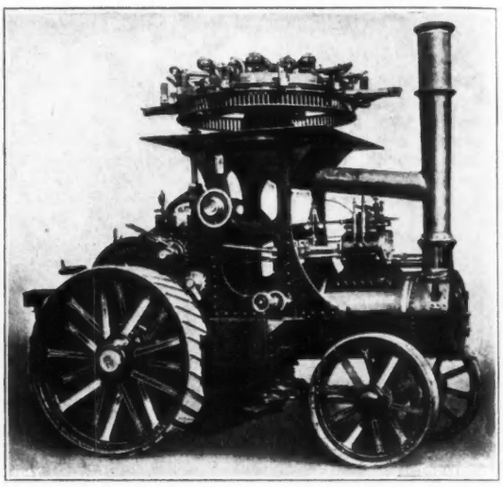


FIG. 24. "ENTERPRISE" SINGLE-CYLINDER CENTRE TRACTION ENGINE, BY F. SAVAGE.

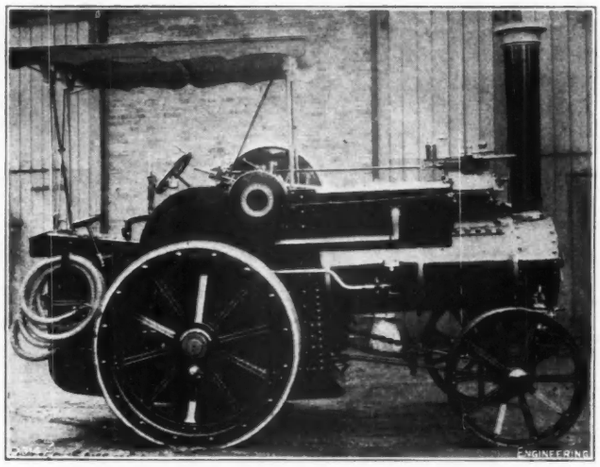


FIG. 25. SAVAGE'S "LITTLE SAMSON" TRACTOR.

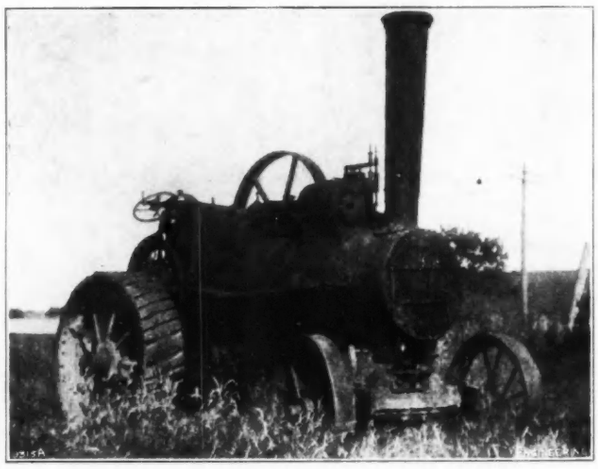


FIG. 26. TRACTION ENGINE, BY WILLIAM WEEKS AND SON, MAIDSTONE.

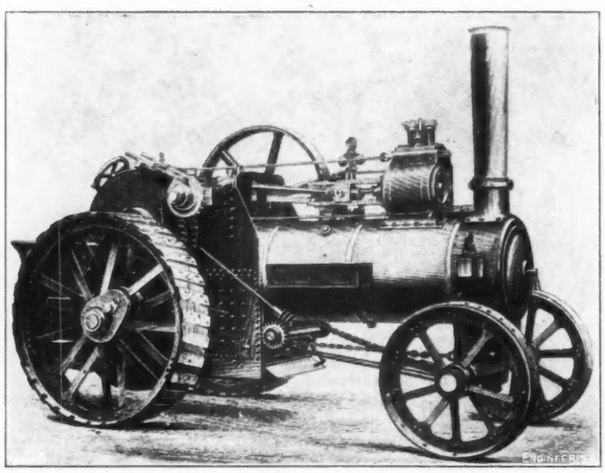


FIG. 27. GENERAL-PURPOSE TRACTION ENGINE; WANTAGE ENGINEERING COMPANY, LIMITED.

FIG. 28. TRACTION ENGINE BUILT FROM MISCELLANEOUS COMPONENTS.

engine, built in 1894, with an annular compound cylinder. It is illustrated in Fig. 22, on page 553, which shows it painted grey, without showman's fittings, and the writer has prepared a drawing of the cylinder, from data supplied by the makers, which is reproduced in Figs. 31, 32 and 33, opposite. Apart from the annular compound cylinder, it was a conventional three-shaft two-speed engine, with extra long brasses

SOME LESSER-KNOWN TRACTION ENGINES.

Fig. 29.

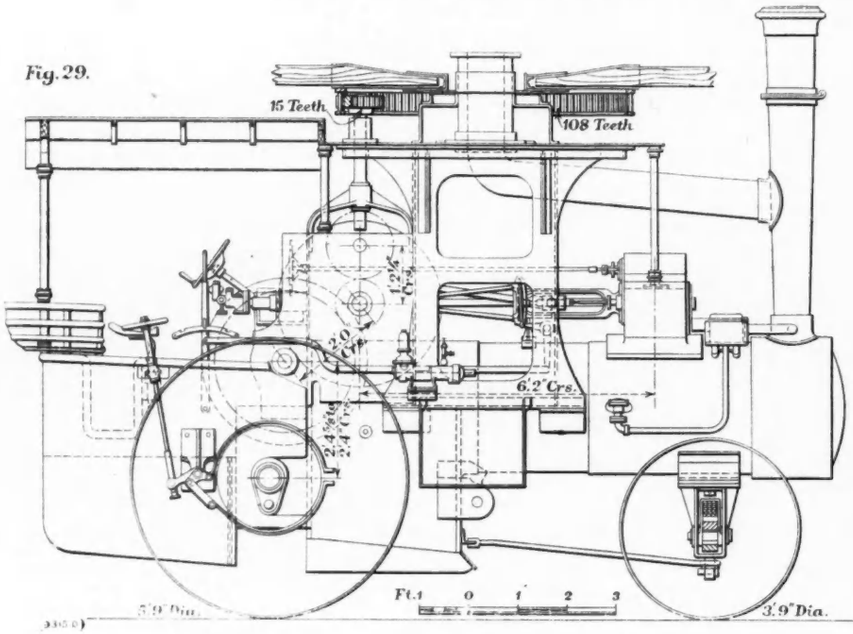


Fig. 30.

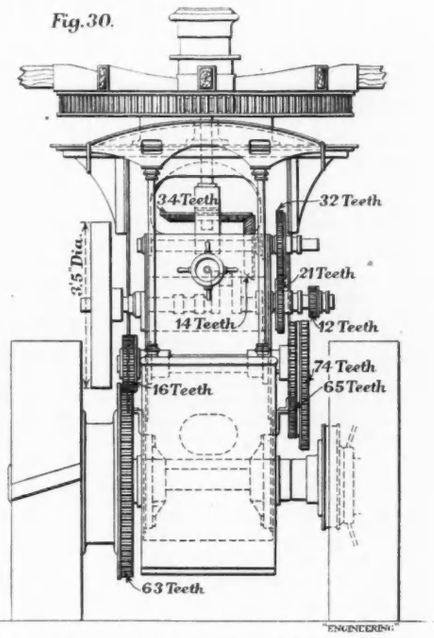


Fig. 31.

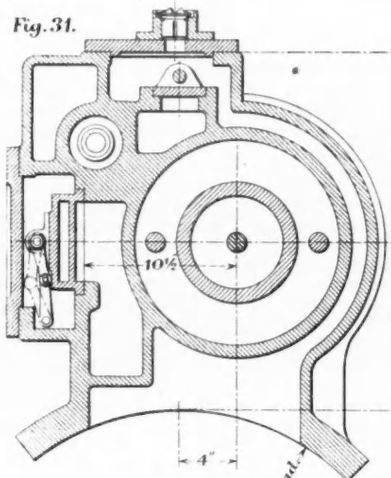


Fig. 32.

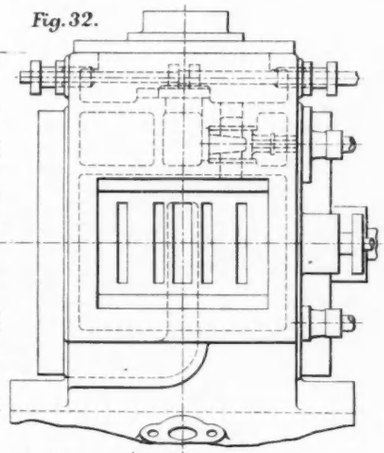
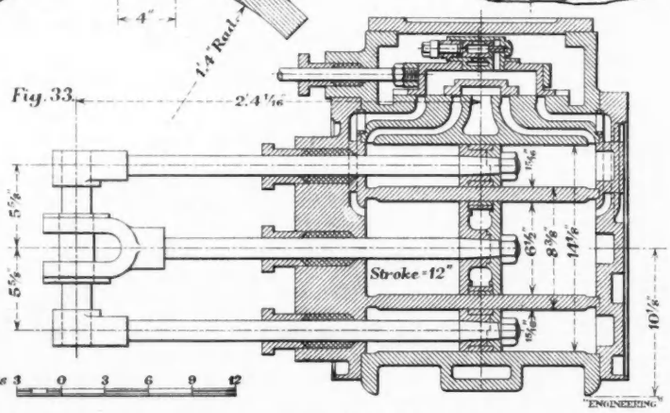


Fig. 33.



to all axles. The high-pressure cylinder was within the low-pressure cylinder, the latter being in the form of an annular cavity, its "piston" having two piston-rods which were joined to the high-pressure piston-rod at a common crosshead. The ratio of the cross-sectional areas of the low-pressure cylinder to that of the high-pressure cylinder was 3·03 to 1. The exhaust steam from one end of the high-pressure cylinder passed through a port cored in the cylinder cover, through the cored slide-valve, through a port in the cylinder block, to the opposite end of the low-pressure cylinder. A by-pass valve on the back of the slide-valve permitted live steam to be admitted to the low-pressure cylinder whenever required. Only one set of Stephenson-type valve-gear was used and the working pressure was 140 lb. per square inch. The engine shown in Fig. 22 was numbered 614 and was supplied to the famous showman, Jacob Studt. It worked with the annular compound cylinders for

TABLE VI.—*Main Dimensions of Savage Traction Engines.*

N.h.p.	6	7	8
B.h.p.	18	21	24
R.p.m.	160	150	150
Working pressure, lb. per sq. in.	120	120	120
Diameter of cylinder in.	8	8¾	9½
Stroke of piston ,,	10	12	12
Diameter of crankshaft ,,	3½	3¾	3¾
,, main axle ,,	4½	5½	5½
Driving wheel diameter ft. in.	5 6	5 9	6 2
,, ,, width ,,	1 4	1 6	1 6
Grate area .. sq. ft.	4·5	5·0	5·7
Firebox heating surface ,,	27·4	34·7	38·8
Tube ,,	90·6	117·8	140·0
Total ,,	118·0	152·5	178·8
Number of tubes	23	30	32
Diameter of tubes in.	2¼	2¼	2¼
Overall length ft. in.	15 10	15 6	16 8
,, width ,,	7 4	7 10	8 2
,, height ,,	10 5	11 5	11 7
Height to top of flywheel ft. in.	8 1½	8 6	8 8
Weight empty tons cwt.	7 15	8 10	9 5

30 years before a new cylinder block was required, but as the makers had mislaid the patterns a normal 8-n.h.p. single-cylinder block was substituted and in this form the old engine is still at work.

The annular compound form, however, was not as commercially successful as the double-crank compound form, and Savage adopted the latter arrangement with side-by-side cylinders in his next design for a showman's engine. The "Empress," as it was called, is illustrated in Fig. 23, opposite. It was a 7-n.h.p. three-shaft two-speed engine with cylinders 6½ in. and 11½ in. diameter by 12-in. stroke, and was built in 1898 to the order of Barker, Thurston and Sons. The vertical side plates, which can be seen in Fig. 23, carried a square horizontal plate, the top which, in turn, supported the footstep bearing of the vertical mainshaft of the roundabout. A small vertical shaft, which protruded above the top of the canopy, was driven by bevel gears off the crankshaft and carried a small pinion at its upper end which drove the toothed wheel of the roundabout. This drive could only be engaged (by a dog-clutch) after the road gears had been slid into neutral, because the shift levers were interlocked. This type of engine for supporting and driving a roundabout, called a "traction centre engine," was originated by Savage to replace the previous centre engines which were not self-propelling and, therefore, were very cumbersome when moving from one fair ground to another. When in use as a centre engine, the vertical chimney was

blanked off and the exhaust passed through the inclined flue and out through the hollow vertical shaft. Fig. 23, page 554, shows a small engine on a bracket at the front for driving the roundabout organ, but later engines were fitted with a dynamo in that position for supplying electric light and power, and the organ engine was put elsewhere, either on the traction engine or on the roundabout. Another example of a traction centre engine, called "The Wonder," is illustrated by the drawings reproduced in Figs. 29 and 30, on page 555, which shows the constructional details and gear sizes. "The Wonder" was a compound engine with cylinders similar to the "Empress" and the slide valves on the outer sides of the cylinders for convenience. It was supplied to Pat Collins, a showman of Walsall, about 1899. The large gear on the roundabout centre—the cradle wheel, as it is called—was built up of 108 pins 1 in. in diameter, pitched $2\frac{1}{8}$ in. apart on a pitch-circle diameter of 6 ft. 1 in. The gear reduction ratios from the crankshaft were: 26·64 to 1 for the roundabout, 12·18 to 1 for the high-gear road-wheel drive and 24·28 to 1 for the low-gear. Savage also made a traction centre engine in single-cylinder form, one of which, called "Enterprise," is illustrated in Fig. 24, page 554. It was an 8-n.h.p. engine with the organ engine mounted on the side of the right-hand supporting plate. All his showmen's engines were finished and painted in a very ornate style.

In common with other traction-engine builders, Savages' also produced a light tractor which weighed less than 5 tons unladen to comply with the Heavy Motor Car Order of 1903. It was a 4-n.h.p. single-cylinder two-speed engine called "Little Samson" and is illustrated in Fig. 25, page 554. The cylinder was 6 in. in diameter by 9 in. stroke. The boiler was 1 ft. $11\frac{1}{2}$ in. inside diameter by 4 ft. $4\frac{1}{2}$ in. between tubeplates, and it had 29 tubes of 2-in. outside diameter. A cylindrical exhaust feed-water heater was fitted below the cylinder block on the near side. The rear axleboxes were provided with coil springs of rectangular cross-section and the front axle was fitted with a semi-elliptic spring. The gear ratios were 8·41 to 1 and 16·53 to 1. A differential and a screw-down externally-contracting brake, adjacent to the right-hand wheel, were incorporated. The principal dimensions were: overall length 13 ft. 8 in., overall width 5 ft. 9 in., rear wheels 4 ft. 6 in. diameter by 10 in. side, front wheels 3-ft. diameter by 6 in. wide, wheelbase 7 ft. 1 in. Several of these engines, including the one illustrated in Fig. 25, were shod with hardwood blocks on the rear wheels. The "Little Samson" was also made with full showman's fittings and equipment, the last to be made being turned out in this manner and supplied to Mr. H. Studt in 1910. A special "Little Samson" tractor of 4-5 n.h.p., having a cylinder $6\frac{1}{2}$ in. diameter by 9-in. stroke, was made in 1910 and exported to Norway. Visitors to the works at King's Lynn and the founder's cottage birthplace at Hevingham, Norfolk, will observe, in the railings around the offices of the former and in the garden gate of the latter, a cast-iron plaque bearing in relief a representation of Frederick Savage standing in his first traction engine.

A small number of engines were made by Messrs. William Sparrow, Limited, of Martock, Somerset, and some of them are still at work in the west of England. They are a straightforward three-shaft design, generally similar to the engines made by Wallis and Steevens, Limited, of Basingstoke, Hampshire. William Weeks and Son, of Maidstone, Kent, who are better known for their agricultural implements, also made a few traction engines. Fig. 26, page 554, shows one of these—probably the last—which was working in Kent until the outbreak of the recent war. They were single-cylinder four-shaft engines with a good reserve of steam, double Salter-type safety-valves and trunk crosshead guides. The cylinder was steam-jacketed, the jacket terminating in a small flat dome above the valve chest to carry the safety-valve seatings. The right-hand end of the crankshaft projected several inches beyond the bearing so that any size of pulley could be fitted when required.

The Wantage Engineering Company, Limited, Wantage, Berkshire (originally P. and H. P. Gibbons, and then Robinson and Auden), being situated in the Vale of the White Horse, fixed a transferred design of a white horse rampant to their traction-engine boilers. Their engines may be recognised by this mark, but it should not be confused with the horse rampant of Kent, which is the mark of Messrs. Aveling and Porter, Limited. One of their 8-n.h.p. three-shaft engines is illustrated in Fig. 27, page 554, with the high-gear crankshaft pinion outside the low-gear pinion. The likeness to Messrs. Burrell's engines, especially in the cylinder block, hornplates and flywheel, will be noted. A few of these engines are still working in the South Midlands. They had cross-armed governors actuating an equilibrium throttle-valve, and a winding drum on the left-hand side, with 50 yards of wire rope $1\frac{1}{2}$ in. in diameter. The principal dimensions were: cylinder, 9 in. diameter by $10\frac{1}{2}$-in. stroke; rear wheels, 6 ft. diameter by 1 ft. 4 in. wide; front wheels, 4 ft. diameter by 8 in. wide; working pressure, 150 lb. per square inch; gear ratios, 25 to 1 and 13 to 1, corresponding to $1\frac{1}{2}$ and 3 miles per hour; water capacity, 135 gallons; overall length, 17 ft. 3 in.; overall width, 7 ft. 3 in.; weight, 10 tons. Their road engine had a single cylinder, a plated flywheel, and a winding drum combined with the differential—another Burrell feature.

Although these notes on little-known traction engines have been arranged by the names of manufacturers, there were a number of engines which were built up, here and there, from parts by several makers. A typical example is illustrated in Fig. 28, page 554, which included a Fowler boiler and rear wheels, McLaren cylinder and motion, Savage and Wallis and Steevens gears, Savage gearcase, Fowell front axle and wheels, and numerous other fittings from scrapped engines by various makers. The owner of this engine told the writer that, as the diameter of the Fowler boiler was greater than the McLaren cylinder seat, and no boring machine was available, the surplus metal of the cylinder was removed by hand hammer and chisel. He also had some difficulty in deciding what name of maker to declare for licensing purposes, but he finally chose Fowler.

The writer is not so sanguine as to suppose that the foregoing survey is complete; it is quite possible that there are other engines—probably "one-off" jobs—which have never been described, and it may be that data concerning them will yet come to light. There is a project to preserve some of these attractive examples of local engineering skill, and owners who wish to save old engines from the scrap heap are invited to communicate with the writer through the Editor of ENGINEERING.

LITERATURE.

La Foudre. By PROFESSOR CHARLES MAURAIN. Collection Armand Colin No. 248. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5). [Price 120 francs.]

PROFESSOR MAURAIN was among the early contributors to the Collection Armand Colin, and his *Physique du Globe*, first published in 1923, included a chapter on atmospheric electricity. He devotes the whole of the present volume to an exposition of those aspects of atmospheric electricity which conspire to produce one of the most awe-inspiring of natural phenomena, the lightning discharge. The electrical nature of the lightning flash was experimentally established towards the middle of the Eighteenth Century by Benjamin Franklin, who also introduced lightning conductors for the protection of buildings; but it was not until the Nineteenth Century, when clear ideas concerning the mechanism of ionisation had been developed, that any satisfactory theoretical interpretation of the accumulation of charge in a thunder cloud could be undertaken, and even now some details of the process remain obscure.

In the preliminary survey of the general electrical properties of the atmosphere, the magnitude and direction of the normal potential gradient is discussed, together with its variation with altitude, and the causes of ionisation giving rise to the observed average air-earth current are explained. While the normal potential gradient at ground level, which is of the order of 100 volts per metre, decreases to one-tenth of this value at a height of some 6 km., the air conductivity at this height is some twenty times its ground value. Fundamental ideas concerning the electrical phenomena manifested in thunderstorms are outlined in Chapter II. The author points out that it is inadmissible to treat the thundercloud as an electrified conductor and that a lightning flash is not an oscillatory phenomenon like a condenser discharge; it is unidirectional, consisting of high-intensity surges separated, in time, by intervals during which the current is too feeble to measure. Various experimental devices for studying the lightning discharge are then described. Among them are the special cameras developed by Boys, the application of the cathode-ray oscillograph to intensity measurements, the use of the capillary electrometer by C. T. R. Wilson for determining variations in the electric field, and the more recently introduced radio techniques for measuring changes in the associated magnetic field.

Chapter IV is concerned with the structure and properties of lightning. The potential gradient near the ground beneath a storm cloud may rise to 20,000 volts per metre and the difference of potential between cloud and earth to 60 million volts. The quantity of electricity passing in a flash, lasting a thousandth of a second or longer, averages 30 coulombs, so that, adopting the conservative estimate of 100 flashes over the earth's surface in each second, the power transmitted amounts to several kW per sq. km. The relatively rare phenomenon of ball lightning is mentioned and notes are added on the spectra of lightning and on thunder. An account of the formation and distribution of charges within thunder clouds follows, wherein attention is directed to the fact that, at the low temperatures prevailing in the upper portions of such clouds, water can only exist in the solid state. The next two chapters are devoted to theories of the production of electricity in storm clouds and the mechanism of the lightning discharge. Various explanations of the generation of electricity in clouds have been advanced, from the breaking-drop theory to the photoelectric action of ultra-violet radiation from the sun on the ice crystals in the upper layers of the cloud. No single theory appears competent to explain all the effects observed and it is probable that more than one agency is at work. The precise mechanism of the discharge is also uncertain; in some way, the leader stroke blazes a trail while the return stroke conveys the main discharge, which travels through the ionised air at a speed between 10^9 and 10^{10} cm. per second.

Attempts at estimating the respective contributions of lightning and rain towards maintaining the earth's negative charge are made in Chapter VIII; Chapter IX describes the modern methods of recording atmospherics and of locating the disturbances responsible for them; and the final chapter deals briefly with lightning conductors and is followed by an extensive bibliography. The account has been brought up to date by adding at the end of certain chapters, during proof reading, summaries of papers published since the completion of the manuscript. Two minor misprints were noted: towards the top of page 90, km^3 should read km^3 and towards the bottom of page 91, v/m should read v. Only a geophysicist of Professor Maurain's distinction could have presented so intricate a subject at once so lucidly and so authoritatively.

The Differential Analyser. By J. CRANK, M.Sc. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 10*s.* 6*d.* net.]

IN recent years, important improvements have been made in the development of machines for the numerical evaluation of differential equations having no formal solution. The idea of such machines, known as differential analysers, is due to Lord Kelvin, who, in 1876, described how a number of integrators could be connected together so that the assembly would be constrained to solve any type of ordinary differential equation. Accordingly, the modern mechanical differential analyser, in which

flexibility and ease in dealing with a wide range of types of equation are combined with a high degree of accuracy, is a valuable instrument in various branches of science and technology, engineering and chemistry, as well as mathematics and physics. For engineering readers, the practical value of Mr. Crank's book is enhanced by the arrangement of the subject-matter, in which the first two chapters are devoted to constructional details of a full-size machine, on the one hand, and, on the other, of a small-scale model such as might be constructed largely with Meccano standard parts.

Although written in the first place for potential users of the analyser, the book nevertheless merits the attention of those in charge of mathematical courses of study for engineers and others, who may well feel the need for a small-scale machine in the laboratory. Operation of the machine would give the student a deeper insight into the significance of differential equations, and, at the same time, improve his knowledge of mechanisms, since the essential preliminary work on paper is followed by the task of making a drawing showing all the units, gears and connections exactly as they are to be set for the problem under consideration. In the subsequent development of standard functions, it soon becomes evident that any reasonable function of any one of the variables occurring in an equation can be fed to the machine by an operator using the input table, a useful example of which is given in Chapter V. It is not without interest to the student of engineering to note that the chief restriction is that the gradient of the input curve must never be so great that the handle cannot be turned fast enough to keep the pointer on the curve.

Point is given to what the author has to say on the economic use of the machine by the fact that the time required to complete a set-up diagram, and to arrange the shafts and gears of the interconnecting system in accordance with this diagram, is determined by the nature of the problem. If the equation is simple, or of a type previously dealt with, a few hours may suffice; for a difficult or an entirely new equation, however, several days may be needed to arrange the machine in the best way. The time of running for each solution also varies, from a few minutes to an hour or more, depending on the nature and the range of the solution required, but this may be reduced by avoiding as much as possible the use of steep input curves and the necessity for frequent scale changes. These and several other topics of practical value enter into the text in an orderly manner, with the result that it may be read with pleasure and profit by the serious reader of engineering literature. It is also instructive to study the methods which have been found practicable so far for the approximate solution of certain types of partial differential equations, of which the heat-conduction equation is one, in Chapter VII, where some indication is given on the limitations attached to each of the methods discussed. The use of elaborate electrical devices in the differential analyser now in course of construction for the Massachusetts Institute of Technology indicates the trend of future development, in the matter of both size and accuracy, as the automatic setting mechanism for the integrators, amounting to 30 in all, will set the units with an estimated accuracy of one part in 150,000, in terms of the extreme displacement from the centre of the tape.

COKE WAGONS.—The Railway Executive have arranged for 1,000 mineral wagons to be fitted with railed extensions to the sides and ends. They will be used for the carriage of coke, the output of which is increasing.

VIBRATION AND SETTLEMENT OF PILES.—The results of some tests on the settlement of piles due to vibration are given in *Engineering News-Record* of May 13, 1948. The tests were carried out at Schenectady, N.Y., in connection with the construction of a new plant for the manufacture and testing of turbines by the General Electric Company, and were instituted owing to the great weight of the equipment which will be installed and the known tendency of the ground to allow settlement. Friction piles under static load, which had ceased settling, were subjected to vibration, generally at resonant frequency, by a rotating out-of-balance disc. It seemed that the vibration reduced the friction supporting the pile, and the resultant settlement was a function of the static load.

SIZE IN TRANSPORT.*

By ARTHUR GOUGE, B.Sc.

THE problems encountered by other types of transport during their development are, I feel, the problems, in a modified form, which we encounter to-day when we endeavour to anticipate the needs of aircraft operating companies, always realising that different routes have different operational requirements. In spite of the variance between air transport and other means of transport, I believe that, if we can interpret history aright, it should be able to guide us—anyway, as far as broad principles are concerned—so that mistakes which may have been made by our forefathers can be avoided as far as possible.

Any transport system requires a considerable amount of capital, in one form or another, applied to it before it can operate at all: for instance, road transport can function only if there is a reasonable road. Travel by rail can only operate if an enormous amount of capital is sunk in a track and all that goes with a track. As far as sea transport is concerned, its limits are dictated by harbours and docks and the depth of water in the approaches. Air transport can operate only if there is a suitable aerodrome or, in the case of aircraft which alight on water, if there is a reasonable stretch available as a landing area. These requirements, which apply to the particular form of transport, need, as I have said before, a considerable amount of capital, and it is in this connection that it is important to see that the capital is spent wisely and spent with an object in view of allowing the future to develop unhindered by what is done at the time when requirements first become known. It is my intention to confine my remarks, with one or two exceptions, to those forms of transport dealing with the movement of passengers rather than goods, although I think that the arguments may apply substantially to both.

Provision of transport, like any other man-made product, depends for its existence on the laws of supply and demand, and is subject to the same consequences. It is necessary, therefore, to lay down a framework on which to base any opinions regarding this problem: at the same time, not wishing to be too technical or obscure, I intend to express it as simply as possible. To my mind, the major factors which govern a transport system and decide its growth and, therefore, its needs, can be placed under two main headings, namely, the service requirements and the cost requirements. Under the heading of service requirements I would say that there are the four sub-requirements of speed, reliability, safety and frequency of departure. Under the heading of cost requirements we have capital expenditure on the means of transport itself, capital expenditure on ancillary equipment, such as tracks, docks, aerodromes, etc., and general operational expenditure.

I should like for a few moments to say something about the four factors of the service requirements. A transport system of any description is founded because human beings wish to travel between two points at speeds greater than nature primarily intended. If the time taken to travel between these points is considerable, then few people will make the journey, but, if the time of operation is comparatively short, many more will do so. It follows that if the speed of the transport vehicle is increased, the volume of traffic will also increase up to some point which will depend greatly upon the population of the two centres under consideration: hence, the speed of operation is all-important in developing a transport system. One of the first lessons to be learnt, then, is that if you employ a new system of transport which increases the speed of operation, you should plan to deal with a bigger volume of traffic.

If any transport system is to exist, it is essential for it to be reliable. If there are two forms of transport in which the time of journey does not differ greatly, then I think that the more reliable form will carry the larger volume of traffic, due regard being paid, of course, to cost and safety. It is extremely important that the means of transport should be safe and I am of the opinion that it is impossible to place too much emphasis on the safety aspect.

Frequently of departure is a controversial item, subject to widely differing opinions. After studying schedules of all descriptions, I have come to the conclusion that frequency, in general, is related almost solely to the journey time. We find that, over extremely short distances which could well be walked in a matter of minutes, a high frequency must be supplied and, in the limit, the engineer's answer to this is the escalator or moving platform. Over distances and times of five minutes or more, omnibuses with a frequency of the same order or slightly more are satisfactory. Over train journeys of 80 miles or so, taking up the time of about 1½ hours, we find again that the frequency is of the order of an hour or so: over longer train journeys of approximately eight hours, the frequency is about six or eight hours. When we consider seaborne traffic and go to the other end of the scale, namely, the Atlantic crossing, we find that the Cunard Line supplies, on its highest-class service, a frequency of approximately eight days for a five-day journey. It would appear, therefore, that the speed of the vehicle dictates the frequency, and the density of traffic dictates the size of vehicle, unless the latter is restricted by other considerations.

Referring to the cost requirements, it is essential in the long run, in any form of transport, that the receipts should be in excess of the over-all expenditure. However, it is as well not to look at this from too narrow a viewpoint, because an increased volume of traffic will have the effect, in general, of reducing cost of operation and, therefore, should reduce the charges, which again will increase the traffic in much the same way as indicated under speed of operation. So far as capital expenditure on the means of transport is concerned, there is little doubt that in each case the interest on this outlay is reasonably small compared with the other items involved. Capital expenditure on ancillary equipment, however, is an extremely interesting item, because it does vary a great deal with the different forms of transport. It is a difficult task to assess the capital expenditure that has been used over the past century or so on roads, bridges, railway tracks, stations, docking systems, etc., but it is a very necessary part of a transport system; in fact, it is so large that it actually defines the vehicle. Probably the largest item of any transport system is general operational expenditure; this includes wages of operational personnel, fuel, insurance, depreciation, operation of ground aids, maintenance of ancillaries, and so on. It can be influenced markedly by the amount spent on the equipment itself; higher-quality machines in the first instance should not require so much expenditure to operate them. Again it is influenced if it becomes necessary to operate smaller units than the volume of traffic demands.

Having reviewed briefly the variables which are involved in the transport problem, I should like to make the point that the size of any vehicle is determined by the density of the traffic or by the capacity of the ancillaries by which it is handled. I think it is true to say that the transport unit will tend naturally to reach the largest technically possible for the route under consideration, and I hope to bring this out with greater force later. After a certain ratio of the value of the ancillaries to the value of the transport unit is reached, it is impossible, economically, to alter the ancillaries to meet an increase in traffic demand; in other words, the weight of capital sunk in the ancillaries will tend to lead the mode of operation of the transport system along lines which may be obsolete in a very few years. The operators then are faced with either sacrificing a great deal of capital expenditure or running an out-of-date system. This may be possible internally in one country, but it could not last long in international competition.

After these general remarks, it is of interest to inquire how the various well-known forms of transport have met the problem as it has been laid down, and I would like to review briefly the history of the three basic ground systems over the past hundred years. Starting with road transport, we find that, as I said before, the first requirement is a road. Roads as we know them to-day did not appear until the end of the Eighteenth Century, when Telford and MacAdam began their work. These roads were about the same as our secondary ones, and with their advent, development of the stage coach proceeded rapidly. In 1832, a new Act of Parliament permitted stage coaches of all kinds to take up and set down passengers anywhere within a five-mile radius, and the 12-seater inside omnibus became the standard type. After a time the density of traffic grew, and some passengers were accommodated on top of the coach. The Exhibition of 1851 affected the London omnibus, and owners, wishing to increase their accommodation per vehicle, introduced the design known as the "knife-board." About this time there were approximately 800 London omnibuses. In 1858, the London General Omnibus Company was formed, but in spite of attempts to improve the design of omnibuses, the knifeboard type persisted until the 'eighties. In the early Twentieth Century tramway routes became extended, the Underground was electrified and the motor omnibus made its appearance.

The first ten years of the Twentieth Century was a highly experimental time so far as road transport was concerned. Steam-driven and petrol-driven vehicles were introduced together and developed in parallel. Out of the experiments and competition of the first decade of this century emerged the London General Omnibus Company's "B" type omnibus of 1910. This was a 34-seater of 30 h.p., and it became the mainstay of the General fleet for many years. The War of 1914–18 held up omnibus development, but progress was rapid immediately afterwards. The "K" type, a 46-seater, came out in 1919, and the "S" type, a 54-seater, followed in 1920; in 1925, the "NS" type subsequently

* Thirty-sixth Wilbur Wright Memorial lecture, delivered before the Royal Aeronautical Society, London, on Thursday, May 27. Abridged.

became the first closed-in upper-deck omnibus. Consequently, we can see that by 1925 the most economical size of short-distance omnibus had been reached. This was a 56-seater, although 60-seaters were used as long ago as twenty years, but the collection of fares by one conductor made it uneconomical to go larger than a 56-seater. Summarising, we see that, when the omnibus was used for the job for which it was most suited, it reached its optimum size about 25 years ago. Since then progress has not been so obvious as far as the passenger has been concerned, although the technical advances have been great. My point is that, if it were not for practical limitations of operation, the capacity of these road transport units might well be doubled.

Turning now to the history of our railway system, it is interesting to remark that, in common with air transport, it is a comparatively recent invention, road and sea transport having existed from time immemorial. The early history, and indeed the whole history, of rail transport is extremely wide and interesting, so we must not lose sight of the main object, namely, the growth of size. To do this I have selected the locomotives of the famous Great Western Railway, which began operating in 1837. The King George V is to date the largest locomotive built by the Great Western Company. I think that I am correct in stating that it provides adequate traction for the weight and lengths of trains and the gradients of track on the Great Western Railway. I do not consider that it would trouble railway engineers to produce a locomotive of twice or more than twice the tractive effort of the King Class, but I consider that it could not be exploited fully, as the trains themselves are limited by track and platform considerations, and this class is adequate to deal with the present situation. So far as the growth of speed in rail-passenger transport is concerned, the block speeds have improved merely by eight or nine miles an hour over the last 50 years and the general trend indicates quite definitely that an upper limit is being reached as far as speed on the present track is concerned.

In my opinion, this does not mean that rail traffic, particularly passenger traffic, will not be carried at greater speeds, but what it does indicate is that consideration will be given in the very near future to different forms of track, which will enable rail passenger transport to increase its speed very much beyond present-day achievements. From an engineering point of view, I can see no reason at all why rail-passenger traffic should not at least double its speed; in fact, it must do so if it is to live in company with air transport over comparatively short distances.

Speaking on sea transport, we have a different story to tell and a different picture to draw, because this form of transport is not so restricted by ancillary considerations as are the others. By the early Nineteenth Century the steamship was more or less firmly established as a means of travel. However, because of the advent at this time of the famous Clipper ships, it was some time before the steamship was accepted completely for ocean travel. In the 1820's and the 1830's steamships crossed the Atlantic mainly under sail. The history of steam navigation is extremely interesting and involved during this period, so, in order to simplify my point of the natural increase of sea-borne tonnage, it is better to consider the growth of size of ships used by a particular Company operating a particular route. I have chosen, perhaps naturally, the highly successful Cunard White Star Line, operating their Atlantic Mail Service. The Cunard Line began operating in 1840 with four vessels, the Britannia, the Caledonia, the Acadia, and the Columbia, all ships of 1,154 gross tons. To-day this Company is operating the Queen Mary and the Queen Elizabeth, both vessels of over 80,000 gross tons. It will be noted that over a period of 100 years the percentage growth in gross weight is 70 to one. This brings out the remarkable growth of size of a form of transport which has not been shackled by costly ancillary equipment, and which deals with a large volume of traffic over a considerable distance. It is fairly obvious that this rate of increase cannot continue, and this leads one to think that another form of transport is about to come in and start a new era. It is admitted that only the largest of the Atlantic Mail ships of their time have been taken and that there have been subsequent drops in the sizes used, but I think that these have been due to variations in world economic conditions, as well as other things. It is likely that the size of the two Queens is about the optimum that can be handled with the existing docking facilities.

(To be continued.)

INSTITUTION OF NAVAL ARCHITECTS.—The autumn meeting of the Institution of Naval Architects will be held at the Royal Society of Arts, Adelphi, London, W.C.2, from Tuesday to Friday, September 21 to 24. Several visits to works and other places of interest are being arranged. A detailed programme will be issued in due course.

JOHN HENRY HAMILTON AND HIS WORK.*

By H. J. GIBBONS.

(Concluded from page 548.)

ANOTHER patent method of scavenging was taken out in the names of James Atkinson and F. W. Crossley in 1893. This system included a particular conformation of the combustion space to encourage entire evacuation of exhaust products and their replacement by cool air under the sub-atmospheric pressure caused by the impetus of exhaust gases flowing through a pipe, 60 ft. long, to a silencing or expansion chamber. Professor Robinson saw the three engines—two Crossley and one Premier—at Winnington and, in the discussion on Humphrey's paper, described the Crossley engines as being of non-scavenger type, and the Premier engine of scavenger type. It seems, therefore, that by then, the Atkinson method of scavenging had been dropped.

Another link with Hamilton and steam-engine history was that, in the early part of this century, two large single-cylinder scavenging engines were put in at Smethwick for James Watt and Company—still in existence as a subsidiary of W. and T. Avery, Limited.

Many large engines used blast-furnace gas. The Premier Gas Engine Company also made a number of medium-size engines, some of which were sent to Canada for using natural gas. In one case, in the north of England, Hamilton was a successful pioneer in utilising coke-oven gas. When it was known that the Premier Company had taken a contract for using coke-oven gas, some Continental gas-engine experts warned Hamilton that it could not be used successfully because of its high calorific value and its benzine content. Hamilton did have difficulty at first with coke-oven gas, but arranged with the client's engineer to insert absorbent material in the supply pipes to the engines. He tried out some samples in the office at Sandiacre, and absorbed the volatile contents by blotting paper. This showed blots only the size of pin heads, but they were sufficient to cause pre-ignition. Hamilton was very successful with his scavenger system, and the Continental makers copied his methods of scavenging, putting in a number of engines in this country to use blast-furnace gas, and later, coke-oven gas.

Another achievement of Hamilton's was a special engine he designed for the Gas Engine Research Committee of the Institution of Mechanical Engineers. Professor Burstall was in charge of this research work and his report (1908) is still interesting. After considering most of the leading types of engine, he decided it was desirable to use a much higher pressure than the average, without employing water or any other fluid to prevent pre-ignition. The building of the engine was entrusted, through Hamilton, to the Premier Company, He chose a 150-h.p. size, with differential piston, but reduced the diameter of the motor piston from 20 in. to 16 in. Instead of using the standard admission valve at the top and the exhaust at the bottom, an entirely new breech-end was constructed, with the admission valves horizontal, care being taken that the interior of the cylinder should have a perfectly flat end.

The thermal efficiency, on one test, was raised to over 40 per cent., as a result of varying the rate of compression. Apparently, higher compressions were not the only way of increasing the thermal efficiency, as Professor Burstall, in his report, stated that "it is necessary to increase the stroke of the engine in proportion to the diameter, and, in this particular engine, the stroke was one and a half times the diameter," which afterwards became Hamilton's fixed idea. These tests established a world's record in thermal efficiency, and the design arranged with Professor Burstall was similar to that used in Hamilton's large tandem engines. The horizontal valves, operating from the back of the cylinder, were worked with a grooved cam, which Hamilton adopted on all sizes of the large tandem engines with separate scavenging pump.

In addition to his large-cylinder gas engines of scavenger type, Hamilton designed and produced a wide range of non-scavenger type ranging from ½ indicated horse-power to 125 indicated horse-power per cylinder, made with a single cylinder, two twin cylinders with central flywheel, also three and four monobloc cylinders. This type was also made in monobloc double two-cylinder, double three-cylinder, and double four-cylinder sizes. The range of powers was up to 1,000 indicated horse-power in eight cylinders. Later, after the Premier Company became linked with Messrs. Crossley Brothers in 1919, he also designed engines of the *vis-à-vis* type. At one period, between 1905 and 1914, there was a fashion to build vertical gas engines, following demands for high-speed vertical steam engines of the Willans and Bellis types, which many gas-engine makers copied. Many firms in Great Britain were making vertical gas engines in those days; there were four in Glasgow alone, and about a dozen in England.

Hamilton designed and made a special kind of vertical engine which was supplied to the Abbey Mills pumping station of the London County Council for storm-water drainage. Subsequently, engines of the same type were supplied to the Isle of Dogs and to Hammersmith pumping stations, and all the 17 engines of this type made in Hamilton's time are running to-day. His method was to make a vertical engine on steam-engine lines, with crosshead and slides, the bottom end of the single-acting cylinder being closed and fitted with a stuffing box through which the piston rod worked. As these particular engines were of the high-compression type, working at 180 lb. per square inch and non-scavenging At first he used water injection to prevent pre-ignition, but eventually found that this was not necessary if the load on the cylinder was reduced to 70 lb. per square inch m.e.p.

Some years before 1914, a preliminary inquiry was made by the Admiralty for a large gas engine for marine purposes, and Hamilton got out a special design of slow-speed engine arranged for direct coupling to propellers. The inquiry mentioned a comparatively small power, but there was a prospect of requests for units up to 10,000 or 12,000 h.p. Hamilton proposed an experimental unit of 1,500 indicated horse-power, but, in view of the expense, the company only authorised him to design and make an engine of 1,000 indicated horse-power. His design consisted of four double-acting cylinders of the four-cycle type, working on a single crank by means of a triangular connecting rod. The cylinders were 24½ in. in diameter by 30 in. stroke, and the engine ran at 125 r.p.m., thus giving a piston speed of 625 ft. per minute. The policy decision was that, if this size proved successful, he could make a similar type with a larger cylinder, up to 3,000 h.p. on a single crank; and, as he had in mind a type of engine with four cranks, this visualised units up to 12,000 h.p. An engine was completed in 1914 and remained in the works until 1919, when it was placed in Hickman's Steel Works to run on blast-furnace gas. Many critics contended that it would not work satisfactorily, but it did work successfully at Bilston, night and day, until 1946.

Hamilton never attempted to design or make a two-stroke gas engine. At one period, he accepted an invitation from Fullagar to see the first of that designer's two-stroke gas engines at Newcastle-on-Tyne. He discussed this after his return and said that, though there was some clever designing about the Fullagar engine, he could not see it being successful as a gas engine, although it had many possibilities as an oil engine—a prophetic remark.

For many years it was argued that gas engines could not be coupled to an alternator, but Hamilton altered this. Mr. Humphrey said, before the Institution of Electrical Engineers in 1909, that, in the early days, no maker of dynamos could be found who would guarantee any machines coupled to gas engines, as the repeated shock of the irregular working of the gas engine would inevitably break down the insulation; certainly, no maker of gas-engines or generators, for many years, would think of coupling a gas engine directly to an alternating-current machine. Hamilton, I think, was the first man in this country to undertake this. I understand that, in 1894, he supplied a tandem engine to the Star Brush Company, Holloway, with the flywheel machined for a three-phase alternator, not to parallel, and that this was one of the first three-phase machines in this country. The engineer of the Star Brush Company could not get the alternator made, and eventually it was made by himself and his staff.

Hamilton designed a number of engines with alternators mounted on brackets cast on the flywheel arms, to run singly, and eventually undertook a contract to run in parallel. This was done in conjunction with Bruce Peebles and Company, and the sets were sent to Japan in 1912, to run on town gas. The Bruce Peebles alternators were fitted with special damping windings, or, to employ the term then in use, choking coils.

Although the early installations of direct-coupled alternators were successful, in later days some difficulties did arise. One of these occurred in Devonshire, with engines running on wood gas. These were of the three-cylinder three-crank type, and the cyclic irregularity was considered at fault. Electrical contractors blamed the flywheels for being too light, and it was my decision to replace a flywheel by a heavier one, as both the consulting engineer and the electrical engineers insisted on this. When I reported to Hamilton, he just smiled, and said that this would make matters worse. As another contract was going through at the time, he was glad to make this experiment by having alternators brought into the works, coupled to engines for testing, and having heavier flywheels than those calculated. The sets failed to parallel, and Hamilton turned down the wheels to a much lighter weight, which gave much better results. Again, they would not parallel satisfactorily, which showed that cyclic irregularity was not the only difficulty. For both contracts,

* Akroyd Stuart Lecture delivered at University College, Nottingham, on March 19, 1948. Abridged.

more damping windings had to be inserted in the alternators, as was also the case with two other contracts in South Wales. In all four cases, the electrical contractors had to take out the alternators and reconstruct them. After Hamilton's stipulation as to damping had been carried out, the contracts were satisfactorily completed. Hamilton originally maintained that, to obtain low cyclic irregularity in the gas engine, it was necessary to employ four-cylinder engines, with equal firing impulses. He also split the four cylinders into two two-cylinder pairs. He thus accidentally overcame another possible difficulty, namely, torsional oscillation.

After 1918, there was considerable development, in this country and overseas, of the multi-cylinder gas engine with Crossley gas producers. By this time, the demand was almost exclusively for driving alternators in parallel, and the large-cylinder type of Hamilton's engine, with a differential piston for scavenging, was dropped. The non-scavenger type of engine could run at a higher speed, and this type was standardised in fewer sizes, thus allowing for production in greater numbers. These installations have been very successful in many parts of the world, especially when using wood fuel.

For many years Hamilton had not been dealing with oil engines. He did make an early attempt, and took out patent No. 11261 (1894). The engine was shown at the Royal Show, at Cambridge, in 1894, and I assume that petroleum was the fuel. In the prospectus of the Premier Gas Engine Company in 1898 it stated that Professor William Robinson, after exhaustive trials of various oil engines in this country, including the Premier, recommended the latter to his clients, the Detroit Dock Company, of Michigan, and advised them to take up the manufacture in America. After the association with Crossley Brothers, Hamilton designed and developed heavy-oil engines which are used to-day. Before he standardised the multi-cylinder non-scavenger type of oil engine, he experimented with a two-cycle engine and made a scavenging pump (which is necessary for a two-stroke engine) by utilising a differential piston of similar type to those used in his early positive-scavenger gas engine, the small end of the piston being the motor end, and the large end being utilised for the scavenger pump. This type was not proceeded with. The first two four-stroke oil engines were sent to Australia, in connection with the Sydney Bridge.

Hamilton afterwards designed oil engines of the *vis-à-vis* non-scavenger type. Crossley Brothers had done a lot of work on *vis-à-vis* gas engines and their experience was placed at his disposal. The first contract of the *vis-à-vis* type was for driving refrigerating plant on six ships of the Nelson Line. Considerable controversy arose with their general manager, Mr. A. R. T. Woods, and the contract was provisionally placed with a competitor. Eventually, Woods changed his mind, and the contract was placed with the Premier Company. These engines are still working very satisfactorily, although they were made over 20 years ago. These engines were of the two-crank, four-cylinder *vis-à-vis* type.

Hamilton also designed a four-crank eight-cylinder *vis-à-vis* type, and three sets, each of 1,000 brake horse-power, coupled to centrifugal pumps through gearing, were installed in the Middle Level Catchment Area for Fen drainage. He designed for these engines a special type of big end with the connecting rods in line. The first engine of this size and type was the subject of a seven days' continuous test by Mr. W. A. Tookey, after Hamilton had retired. The continuous rated output for six days was 905 brake horse-power, and, on the seventh day, as an endurance test, the engine was run at 1,000 brake horse-power very successfully. These sets have been working for many years.

Hamilton's methods of governing during his period at Sandiacre were very interesting. His first small engines were fitted with governors of the inertia type. As this was rather expensive, and not satisfactory with the "hit and miss" impulses, he altered these to a spring shaft governor, which was less costly. On his large engines, he always fitted centrifugal governors; latterly, first on large engines, and subsequently on all types, the centrifugal governor was used with variable admission. On his gas engines, I think he was the only man to arrange variable admission on the gas only, and this contributed to his success.

In the early days, the method of ignition for gas engines was by heated ignition tube, subsequently changed to electric ignition by battery, and finally to magneto-electric ignition. In his larger sizes of cylinders, the sparking points were in duplicate, and arranged so that one set could be withdrawn for cleaning or renewal without stopping the engine. He also adopted a duplicate method of springs for operating the admission and exhaust valves—an ingenious arrangement, as, if one spring broke, the engine could still operate while the replacement was made.

I believe that Hamilton was also the pioneer in the introduction of water-cooling of pistons and exhaust valves in the large slow-speed gas engines. In the early period of the large gas engine, there was much difficulty starting. Compressed-air starting was not then in use, and electric ignition was unknown. Tube ignition had taken the place of the slide valve. Hamilton devised a hand-pump starter, which introduced and metered a number of charges of gas and air into the cylinder, the mixture being fired from the ignition tube by means of a timing valve. Subsequently, he designed and fitted an automatic arrangement by means of which compressed air was admitted into one or more cylinders, while firing took place in the others. Teeth were cast in the flywheel rims and a pinion engaged these by means of a handwheel. On some of the large-cylinder engines with heavy flywheels, Hamilton provided a compressed-air motor for barring.

In addition to being an engine designer, Hamilton had a remarkable genius for designing machine tools. In many cases, in the works, when he had difficulty in getting things made, he designed and made complete tools for special purposes, and a number of these are still in use. For two large engines supplied to chemical works in the Midlands for driving alternators (not in parallel) he designed a special flywheel, about 12 ft. in diameter, the poles of the alternators being fitted into the flywheel rims. The machining had to be done within close limits, and the special flywheel-turning and boring machine made for this purpose is still used. He also made a large rotary planer; undoubtedly, the pioneer of the present-day "plano-miller." This machine was made for machining the centre and outer girders for his large tandem type of gas engine, some of which were nearly 30 ft. long and weighed over 20 tons when finished. During the 1914-18 war, Robert Armitage, M.P., the chairman of the company, who was also chairman of a large steelworks in Sheffield, wanted to take on a contract for machining crankshafts for aero-engines. The Sheffield company made the forgings, and Hamilton commenced the machining by designing and making special machines for this job for aero engines made by firms in Derby, Bristol and Manchester. A national factory was established in Coventry for the quantity production of crankshafts, based on Hamilton's special machines. He was an excellent mathematician, but he never used a slide rule; he had a method of short cuts in mathematics which he used instead.

Hamilton was not a member of any technical institution, and the only time that he read a paper was before the Staffordshire Iron and Steel Institute at Dudley, in November, 1904, with the title "The Gas Engine in Iron and Steel Works." He was very modest in his claims concerning his own type of engine, but he gave a lot of information on the thermal efficiency of the gas engine of those days in comparison with that of the steam engine. His only reference to his own engine was that the Premier engine differed from the other four-stroke cycle motors, in that it was of the positive-scavenging type. An article appeared in ENGINEERING in 1940, by Mr. W. A. Tookey, entitled "Fifty Years of Pressure Scavenging,"* and this dealt with scavenging and pressure charging over the whole period.

After his retirement, Hamilton was a frequent visitor to the works, several times a week. Many of his inventions are still utilised in the Crossley-Premier engine, such as his combined cylinder and liner, his big-end bearing of the *vis-à-vis* type, and his method of inserting admission and exhaust valves vertically opposite to each other.

After his death in 1932, many references to his work appeared in the Press. One was by his old competitor, Hugh Campbell, who said, "Of Hamilton, as an engineer, no praise high enough can be given; he was predominant, not only in Great Britain, but elsewhere, in the design of the large gas engine, and although German engine-builders were much boomed here during the war of the large blast-furnace gas engines, Hamilton was making such engines successfully on this own line. Later in life, when the gas engine fell out of demand, he began designing and building crude-oil engines and his last effort—a magnificent effort, too—was his 1,000-h.p. horizontal engine, in the Fen district. He possessed robust individuality and high courage, and these he carried right through to the end."

INSTITUTION OF CIVIL ENGINEERS.—The list of officers elected at the annual general meeting of the Institution of Civil Engineers, Great George-street, London, S.W.1, on May 25, to serve during the 1948-1949 sessional year, commencing on the first Tuesday in November, includes the names of Sir Jonathan R. Davidson, C.M.G., M.Sc., as President, and those of Sir Reginald E. Stradling, C.B., M.C., D.Sc., F.R.S., Mr. V. A. M. Robertson, C.B.E., M.C., Dr. W. H. Glanville, C.B.E., and Mr. A. S. Quartermaine, C.B.E., M.C., as vice-presidents.

* ENGINEERING, vol. 149, page 595 (1940).

75-MVA HYDROGEN-COOLED ALTERNATOR FOR LITTLEBROOK POWER STATION.

THE Littlebrook B power station of the British Electricity Authority, near Dartford, Kent, is to contain two generating sets, each with a rating of 60 MW at a power factor of 0·8 and giving a three-phase output of 75 MVA at 11·8 kV and a frequency of 50 cycles per second. These units, which are now being completed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, to the designs of the consulting engineers, Messrs. Merz and McLellan, 32, Victoria-street, London, S.W.1, are interesting for several reasons. They will be the first machines in this country of this capacity to be run at 3,000 r.p.m. The steam conditions will be 1,250 lb. per square inch and 900 deg. F., and re-heating will be employed between the high-pressure and intermediate-pressure cylinders of the turbines. The alternators will be hydrogen-cooled, this again being the first time that this system has been employed in the United Kingdom. One of these alternators is now being erected at Littlebrook, while the other is still on the test bed at Trafford Park, where we had the opportunity of seeing it on load on Thursday, June 3.

The appearance of the completed alternator will be clear from the view showing it on the test bed, which is reproduced in Fig. 1, on page 560, while Fig. 4, on page 564, shows the unwound stator being lowered on to the test-bed, and Fig. 5, on the same page, shows the four openings in which the hydrogen coolers, referred to later, are inserted. As regards the design of the alternator, the electrical windings and magnetic circuits follow conventional practice, except for the shaft seals used in connection with the hydrogen cooling. The machine is fitted with bracket-type bearings and the frame has been made exceptionally strong in order to support the heavy brackets carrying the rotor. The weight of the rotor is 32 tons and that of the stator, including the gas coolers, 151 tons. Current for excitation is supplied from a separate motor-driven exciter and is led to the rotor winding through the slip rings shown at *a* in Fig. 2 on page 560. As will be seen, these rings are housed in a separate chamber, which will be ventilated by air drawn from the engine room through a filter.

The arrangement of the hydrogen cooling circuits is also shown in Fig. 2, and that of the four horizontal gas coolers which, as already stated, are housed in the frame, will be clear from Fig. 3. These coolers consist of nests of finned tubes, similar to those used on closed-circuit air-cooled machines. They are flexibly mounted, so as to prevent any vibration from being transmitted to them from the stator frame and to allow for differential expansion. To fill the machine with hydrogen, the air is first removed from it by admitting carbon dioxide from the bottles *b* through the manifold *c*. When a gas concentration of 70 per cent. has been obtained, the carbon dioxide is displaced by hydrogen, which is obtained from the bottles *d* through the manifold *e*, until the pressure in the casing is 0·5 lb. per square inch, and the purity is 97 per cent. It may be noted that hydrogen will not support combustion so long as its purity is maintained above 75 per cent., so that there is no risk of fire occurring in the machine. During operation, the hydrogen is circulated through the gas coolers *f* and the stator and rotor by the revolution of the latter.

In order to prevent gas leakage at points where the rotor shaft passes through the ends of the stator frame, seals, *g*, of the oil-film type are provided. As will be seen from Fig. 2, these are mounted on the bearing brackets between the alternator side and the bearings. Each seal consists of two segmental rings, which surround the shaft and are held in position in their housings by garter springs. The clearance between these rings and the shaft is less than the main-bearing clearance. The oil for the seals is drawn from the main lubricating system and is supplied by an independent oil pump *h* through the cooler *i* to the annular spaces between the seal rings *g* at each end of the shaft. The oil flowing towards the alternator absorbs hydrogen, and that towards the bearing absorbs air. It is, however, prevented from being drawn into the alternator by baffles and, as it has been vacuum-treated, it will neither release air into the alternator, nor hydrogen into the bearing oil. The hydrogen-contaminated oil, on leaving the seals, passes into the seal drain *k* and thence to the hydrogen de-training tank *l* and the vacuum tank *m*, in which vacuum is maintained by the pump *n*. Similarly, the air-contaminated oil from the alternator passes into the air-detraining tank *o*, and thence to the vacuum tank *m*, where it is mixed with the oil from the seals, and is returned to the main bearing-oil tank, which is not shown in the diagram. Make-up oil is also drawn from the main bearing-oil tank into the air-detraining tank *o*, by a pipe which is not shown, and thence into the vacuum tank *m*. The seal-oil pump *h* thus obtains a supply of oil which

contains neither air nor hydrogen and passes it through the cooler *i* to the seals *g*, as already described.

The oil in the seals is maintained automatically at a pressure above that of the hydrogen in the machine casing by a differential pressure regulator *p*. The normal operating pressure of the hydrogen is 0·5 lb. per square inch above that of the atmosphere and this is automatically maintained by a regulating valve *q*, which is located between the hydrogen bottles *d* and the machine frame. In the event of a failure of the seal-oil pump *h* or the supply to its motor, oil is automatically admitted to the seals from the main-bearing supply line through the valve *n*. Both the hydrogen and the carbon dioxide can be released to the atmosphere through the vent *s* by operating the appropriate valves *t* or *u*. A liquid detector *v*, with an alarm, is connected to the bottom of the machine frame to give warning of the presence of water or oil in the hydrogen. Some of the circulating hydrogen is also continuously by-passed through the silica-gel dryer *w*, which enables the whole of the gas to be treated two or three times a day. The hydrogen and air detraining tanks *l* and *o*, as well as the vacuum tank *m*, are housed in the cylinder, which is illustrated in Fig. 6, on page 564. This cylinder, together with the associated pumps and motors and their control equipment, are mounted on a frame, as shown in the same illustration, which will be installed in the power-station basement, as will also the carbon-dioxide and hydrogen bottles.

The gas system and associated plant are controlled from the cabinet illustrated in Fig. 7, on page 564. This cabinet contains gauges indicating the gas pressure inside the machine, the purity of the hydrogen and the fan pressure. It also includes a thermometer to show the hydrogen temperature. In addition, it houses apparatus which gives audible and visible warnings if the hydrogen pressure in the machine exceeds or falls below a given pressure, or if the pressure in the hydrogen bottles becomes less than a certain amount, thus showing that replacement is necessary. Further, the fact that the hydrogen purity has fallen below a safe figure is shown, as are low oil-seal pressures and high oil levels in the seal drain. Other information given is of high and low oil levels in the hydrogen-detraining and vacuum tanks, low vacuum in the vacuum tank, and high and low seal oil-hydrogen differential pressures.

Works tests of such large machines as the alternator we are describing are necessary to prove guarantees and to furnish design and operating data. They are particularly essential in the many cases where it is not practicable to carry them out immediately after installation on site. As, however, it is impossible to test such an alternator under actual full load except on site, works tests must frequently be limited to the measurement of the losses on no-load and short circuit with, if possible, heat runs on open circuit with normal voltage and on short-circuit with the full-load current in the stator winding. Even for these tests, however, it is often difficult to provide mounting facilities for a large alternator and its driving motor and the necessary power for the latter. The Metropolitan-Vickers Electrical Company have therefore adopted a method of testing which is claimed to give a close approximation to full-load conditions although the power used is only a small proportion of that which corresponds to the rated capacity of the alternator. In this method, the stator is loaded with the full rated current at full voltage, but at zero power factor. No actual power, other than that required to supply the losses, is therefore consumed. Such a wattless load can be obtained by connecting the alternator under test to stationary reactors designed to give magnetising currents of the required voltage. A load which is at nearly zero power factor is thus provided and a heavy current can be obtained with a comparatively small expenditure of power. The use of this method also economises space on the test bed and ensures that the testing programme will not be dependent on the availability of other machines, as it would be if one or more alternators of similar aggregate capacity were used to provide the load.

To carry out tests in this way, the large electrical machine test bed at Trafford Park has been equipped with two oil-immersed water-cooled reactors of special design. These reactors have a nominal rating of 20 MVA at 6·6 kV, but can provide a continuous load up to 22 MVA. In conjunction with the motor-generator equipment in the department they enable a total loading capacity of 60 MVA to be made permanently available. They are of the three-phase core type, the cores being rectangular in cross section and containing horizontal ducts for cooling purposes and so that the necessary reluctance can be obtained. The winding on each leg is divided into two equal parts, which may be connected either in series or parallel. Each part consists of a number of section-wound coils connected in parallel with horizontal ducts between the coils. The conductors are insulated with paper; and the windings on each leg are held, top and bottom, between end plates of non-magnetic material. These end-plates are clamped by manganese-bronze bolts, which are

75-MVA HYDROGEN-COOLED ALTERNATOR.

MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

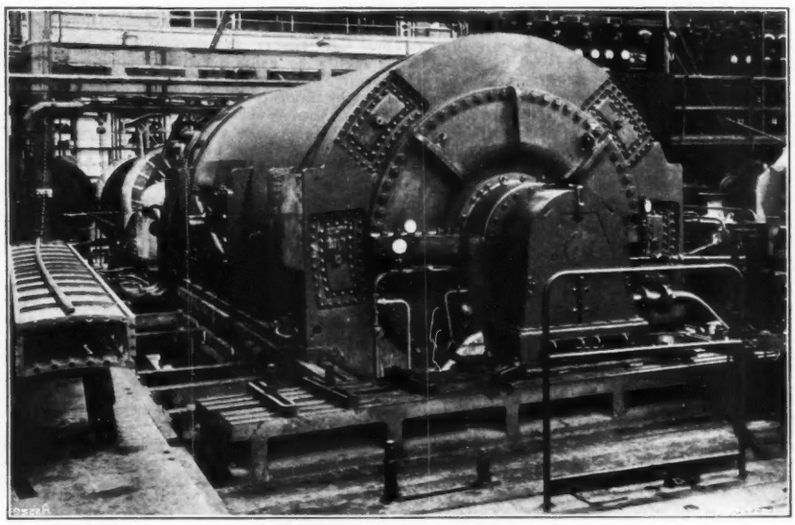
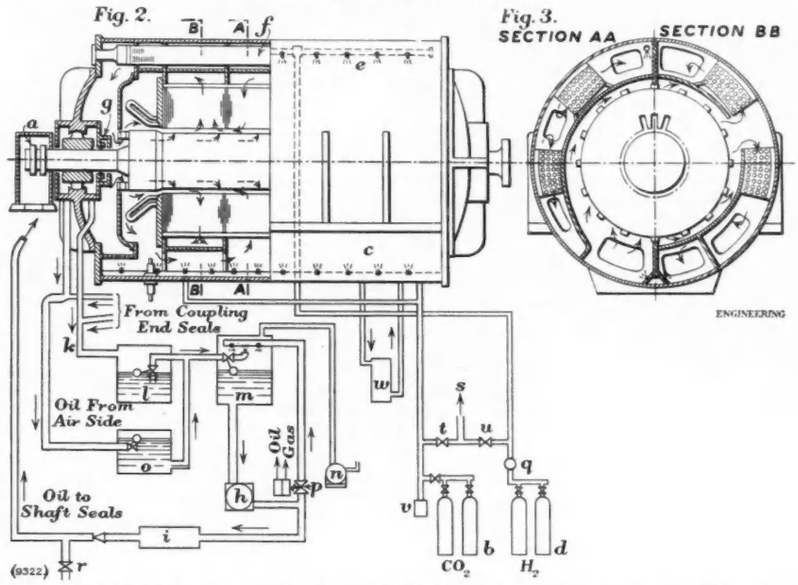


FIG. 1. MACHINE ON TEST BED.



located outside the coils. The oil is cooled by water circulation in a coil of tinned-copper tubes, which is mounted in the upper part of the tank below the oil level. To facilitate the changing of connections, the section and phase leads are connected by heavy cables to a separate switchboard, which consists of knife switches mounted on an ebony-asbestos base. The reactors alone can be used to provide the wattless load by coupling the alternator directly to them and driving it at synchronous speed with full excitation by a direct-current motor, which supplies power to make up the losses. When the tests require greater kVA values than the capacity of the reactors, the latter are supplemented by one or more alternators, which are also driven at synchronous speed by motors.

To carry out the test the alternator is solidly connected to the reactors and, if necessary, to the other machines, the fields of which are left open. A motor-generator set consisting of a 6,000-kVA alternator driven by two 500-kW direct-current motors is then run up to speed from the direct-current side and synchronised on to the 6·6-kV feeder from the works sub-station. The direct-current machines are now available to supply a separate set of 'bus-bars for Ward-Leonard control which is used to run the alternator under test up to synchronous speed. This is effected by a 2,500 h.p. motor which is connected to the test alternator through gearing. The test alternator and, if used, the load-alternators, are then gradually excited until they fall into step; and the excitation is increased until normal voltage is obtained. The next operation is to increase the excitation on the test alternator and decrease that on the load alternators until the kilovolt amperes required are obtained at zero power factor, the voltage being maintained at its full value. The complete alternating-current system is then paralleled with the 6·6-kV feeder, the losses being transferred to the latter by strengthening the fields of the direct-current motors and alternators. All the direct-current machines are then disconnected from the 'bus-bars leaving the alternators running as synchronous condensers. Finally, the capacity of the 6,000 kVA alternator mentioned above is added to the load.

For test purposes, the Littlebrook alternator was first arranged for air cooling and driven by a calibrated direct-current motor to determine its open- and short-circuit saturation curves and losses. Under these conditions it was also subjected to a number of sudden three-phase and two-phase short-circuits with the full voltage across the terminals. It was then run on a load of 60 MVA, obtained in the way just described, at zero power factor, air still be used for cooling with a restricted water supply flowing through the hydrogen coolers. As a result, we understand, the temperature rise was found to be within the limits permitted by the appropriate British Standard Specification, while the efficiency calculated by the summation of losses method was 97·7 per cent. at this load and a power factor 0·8.

HORIZONTAL DIESEL ENGINE.

LEYLAND MOTORS, LIMITED, LEYLAND, LANCASHIRE.

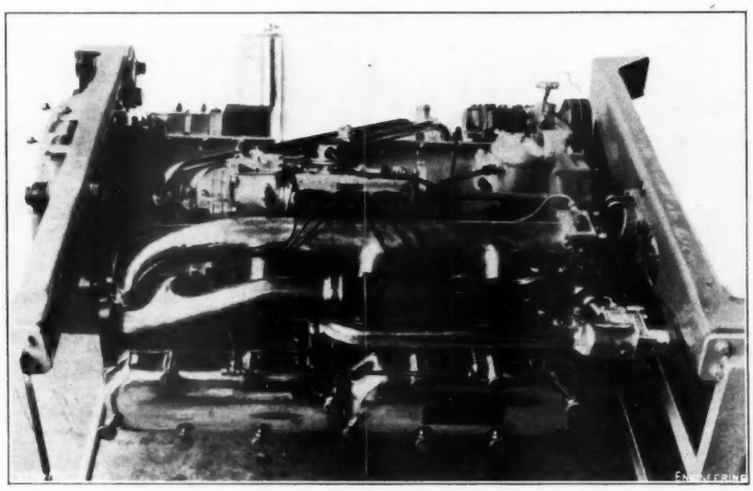


FIG. 1.

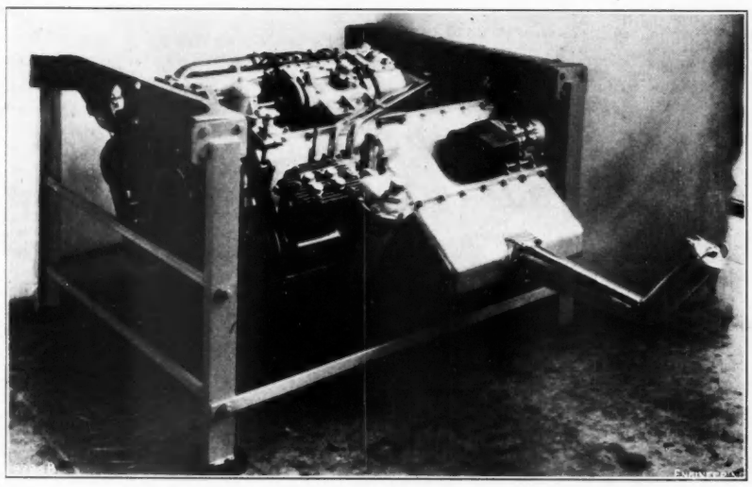


FIG. 2.

The air was then removed from the machine by admitting carbon dioxide. When this gas had reached a concentration of 70 per cent. it was displaced by hydrogen, until the pressure in the casing became 0·5 lb. per square inch above that of the atmosphere; and the purity reached a value of 97 per cent. The machine was then again driven by the calibrated direct-current motor and the open-circuit, short-circuit, winding and friction losses were determined. Under these conditions the efficiency of the alternator as a hydrogen-cooled machine was 98·5 per cent. on a load of 60 MW with a power factor of 0·8. We understand that the machine was much quieter when operated on hydrogen than in air.

The next series of tests began on Saturday, May 29, when the alternator was subjected to temperature runs at loads of 60 and 70 MVA at zero power factors, two reactors with a combined capacity of 44 MVA, a 20 MVA synchronous condenser, and a number of motor-generator sets being used as a load. In order to reduce the conversion losses during these temperature tests, which were made with hydrogen pressures of 0·5 lb. per square inch and 15 lb. per square inch in the casing, the alternator was synchronised with the British Electricity Authority's system and run as a synchronous motor. With a load of 60 MVA the temperature rise of the stator windings, measured by thermocouples between the coils, was about 45 per cent. lower with hydrogen at 0·5 lb. per square inch than when operating in air at atmospheric pressure, while when the hydrogen pressure was increased to 15 lb. per square inch, the rise was 60 per cent. lower. The temperature of the stator winding with a load of 75 MVA and hydrogen cooling was also 20 per cent. lower than with a load of 60 MVA and air cooling. The leakage of the hydrogen during the casing tests at 0·5 lb. per square inch was small and the cost of replacing it, it is stated, did not exceed 8*s.* a day. It may be added that the cost of removing the air by carbon dioxide and replacing the latter by hydrogen at a pressure of 0·5 lb. per square inch is about 10*l.* 10*s.*

In conclusion, the considerations which have led to the adoption of hydrogen-cooling for large generators may be briefly stated. They are a reduction in the noise and windage losses owing to the fact that the density of hydrogen is only about one fourteenth that of air. The heat-carrying capacity of hydrogen is also about fourteen times and its heat-transfer coefficient about 50 per cent. higher than that of air. It therefore absorbs heat from the machine more easily, and discards it more readily in the coolers. As the thermal conductivity of hydrogen is about seven times that of air the thermal drops between adjacent parts of the machine are lower. The employment of hydrogen also almost completely eliminates the losses due to corona and prolongs the life of the insulation and reduces maintenance costs owing to the fact that the machine is completely sealed.

NORTHERN HEIGHTS MODEL FLYING CLUB.—A new trophy, the Queen's Cup for rubber-driven model aircraft, is to be competed for at the annual gala day of the Northern Heights Model Flying Club, to be held on Sunday, June 20, on the Langley airfield of Messrs. Hawker Aircraft Limited, near Slough, Buckinghamshire. There will be also a contest for the Helicopter Trophy for rubber-driven or engine-driven helicopters. Particulars are obtainable from the honorary secretary, Mr. H. R. Turner, 61, Avenell-road, Highbury, London, N.5.

HORIZONTAL DIESEL ENGINE FOR PUBLIC-SERVICE VEHICLES.

THE modern tendency in the design of single-deck public-service vehicles is to place the engine under the floor, as this arrangement allows the passenger entrance to be situated beside the driver and, therefore, gives greater space for the accommodation of passengers. This tendency is more pronounced on the Continent, and in order to meet the demand from Continental chassis manufacturers for an under-floor power unit, Leyland Motors, Limited, of Leyland, Lancashire, have designed the horizontal Diesel engine illustrated in Figs. 1 and 2, on this page.

The unit is based on the 9·8 litre vertical-type engine, currently being fitted by Leylands on their heavy-goods and passenger vehicles, which was described in ENGINEERING, vol. 162, page 272 (1946). The horizontal engine retains the same bore and stroke as the vertical engine, namely, 4·8 in. and 5½ in., respectively, which gives a cubic capacity of 597 cubic inches or 9·8 litres. It develops an output of 125 brake horse-power at the maximum governed speed of 1,800 r.p.m., and a maximum torque of 410 lb.-ft. at 900 r.p.m. The fuel consumption up to 1,200 r.p.m. is 0·34 pint per brake horse-power per hour, from which figure it rises slowly to a consumption of 0·36 pint per brake horse-power per hour at maximum speed, this being an exceptionally good performance for an engine of this type.

The main difference between the vertical and horizontal engines is in the layout of the auxiliaries which have been arranged on the horizontal engine so that those units requiring frequent routine servicing are situated on the top of the engine. The other main points of difference are the incorporation of a new design of sump, the fitting of additional pipes in the water-circulating system to prevent the formation of vapour pockets, the inclusion of drainage pipes on the return side of the lubricating system, and the use of a new three-point flexible engine mounting.

The C.A.V. fuel pump, which works in conjunction with the Leyland mechanical and vacuum-operated governor, is fitted to the top of the engine and occupies the same relative position as the fuel pump on the vertical engine. Slightly forward of the pump, and adjacent the pump drive, is a felt-type fuel-oil filter. An air compressor is situated on the left-hand side of the engine and is fitted to a platform integral with the oil sump. The compressor is driven from the forward end of the crankshaft by twin V-belts and is supplied with lubricant by a small pipe connected into the main lubricating system of the engine. A full-flow cloth-element filter is fitted just behind the compressor and is connected to the oil gallery in the crankcase wall by feed and return pipes. The 24-volt starting motor also is located on the left-hand side of the engine and is fitted just above the oil sump.

A centrifugal-type cooling-water pump is fitted to the forward end of the cylinder block on the right-hand side of the engine; like the air compressor, it is driven by twin V-belts from the forward end of the crankshaft, but the two belt drives are entirely independent. The V-belts for both the cooling-water pump and the air compressor are provided with tensioning pulleys which are fitted to the ends of fulcrum levers. These levers are manipulated by large hand screws, thus making it possible to adjust the tensions in the belts accurately. A cooling fan is not fitted to the engine, but provision is made for taking a propeller shaft from the front of the crankshaft to a fan fitted to the chassis frame forward of the engine. In the case of one omnibus fitted with this engine, the radiator is mounted at the front of the chassis in the orthodox position and the fan is driven by a shaft from the engine, which is fitted in approximately the middle of the chassis. The cooling system, as previously mentioned, incorporates additional pipes to prevent the formation of vapour pockets; these pipes are led from the cylinder water jacket to the inlet side of the thermostat, which is the highest point in the system. A single large cock at the base of the engine drains the complete water-cooling system. Drives for auxiliary equipment can be taken from four points of the engine, namely, the crankshaft, the two tensioning pulleys and the cooling-water pump. These drives are forward of the engine, but a drive to the rear can be taken from one of the tensioning pulleys, if required.

As previously mentioned, a new design of detachable sump has been fitted, the general lines of which will be apparent from Fig. 2. The long-necked filling pipe incorporates the engine-oil dipstick, and the combined filling pipe and dipstick extends 32 in. from the centre of the engine; an alternative pipe can be fitted, however, and this increases the 32 in. to 35 in. so as to give easier access when the engine is fitted in an 8 ft. wide omnibus. A large suction oil filter is fitted in the sump, the capacity of which is 5½ gallons. Lubrication of the engine follows previous practice. A gear-type pump delivers the oil through the full-flow filter to the main oil gallery on the top of the crankcase, and

drilled oilways connect this gallery to the main bearings and big ends, the crankshaft being drilled for big-end lubrication. The big ends are drilled so as to deliver a spray of oil on to the cylinder walls, and in addition to supplying the front main bearing, the forward oilway feeds the idler-gear bearing and the teeth of the timing gears. A drilled oilway across the front of the crankcase delivers oil to the centre of the hollow camshaft which, in turn, delivers the oil to the camshaft bearings. At each revolution of the camshaft, oil is forced from the second and fifth camshaft bearings into holes which pass through the cylinder heads, rocker brackets and hollow rocker shafts to the rocker bearings, pads and valve caps. The oil is returned through drilled ducts to the lower ends of the push-rods and tappets, and from there to the sump by gravity, but in order to maintain the gravity feed two additional external pipes run from the tappet covers directly to the sump. To assist further in oil drainage, the engine is fitted into the chassis frame so that it has a tilt of 3 deg. from the horizontal.

Apart from the modifications detailed above, the engine is similar to the vertical unit. Obviously, the major difficulty encountered in designing the horizontal engine was arranging the ancillary components so as to give a low overall height; this is less than 2 ft., which, considering the output of the engine, is a creditable achievement. Furthermore, although cast-iron predominates in its construction, the weight of the engine, without the dynamo and starter motor, is only 1,630 lb.

LAUNCHES AND TRIAL TRIPS.

M.SS. "SVANESUND" and "SVENSKSUND."—Single-screw cargo vessels, built by Messrs. Furness Shipbuilding Company, Limited, Haverton Hill, Co. Durham, for the Rederi A/B Svea, Stockholm. Main dimensions: 284 ft. by 39 ft. by 22 ft. 11 in. to shelter deck; deadweight capacity, about 1,800 tons on a draught of 15 ft. 3 in. Both vessels fitted with "Fiat" six-cylinder Diesel engines, developing 1,350 brake horse-power in service, installed by Messrs. Richardsons, Westgarth and Company, Limited, Hartlepool. Launch (both vessels), May 11.

M.S. "THORSHALL."—Single-screw cargo vessel built by The Burntisland Shipbuilding Company, Limited, Burntisland, Fife, for A/S Thor Dahl, Sandefjord, Norway. Main dimensions: 390 ft. by 53 ft. 6 in. by 34 ft. 6 in.; deadweight capacity, about 6,000 tons on a draught of 23 ft. 9 in. Hawthorn-Doxford four-cylinder opposed-piston Diesel engine, of 4,400 brake horse-power, supplied by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn-on-Tyne, and installed by the shipbuilders. Launch, May 24.

S.S. "RAMORE HEAD."—Single-screw cargo liner, carrying 12 passengers, built and engined by Messrs. Harland and Wolff, Limited, Belfast, for the Ulster Steamship Company, Limited, Belfast. Main dimensions: 455 ft. by 59 ft. 3 in. by 39 ft. 4 in. to shelter deck; gross tonnage, about 6,050. Parsons double-reduction geared turbines developing 5,000 shaft horse-power, with four oil-burning boilers. Launch, May 25.

M.S. "MERSEY NO. 26."—Twin-screw triple-grab hopper dredger, built by Messrs. Ferguson Brothers (Port-Glasgow) Limited, Port-Glasgow, to the order of the Mersey Docks and Harbour Board, Liverpool. Main dimensions: 237 ft. by 40 ft. 6 in. by 17 ft. 3 in.; draught, 14 ft. 3 in.; hopper capacity, 1,350 tons. Three Paxman twelve-cylinder four-stroke Diesel engines coupled to three Metropolitan-Vickers inter-pole generators. Launch, May 25.

M.S. "BRAGANÇA."—Single-screw cargo vessel, carrying 12 passengers, built and engined by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, for the Sociedade Geral de Commercio, Industria e Transportes, Ltda., Lisbon. Main dimensions: 424 ft. by 53 ft. 9 in. by 25 ft. 6 in.; deadweight capacity, about 7,100 tons. Doxford four-cylinder opposed-piston oil engine giving a service speed of over 13 knots. Trial trip, June 1.

S.S. "ALBISTAN."—Single-screw cargo vessel carrying four passengers, built by Messrs. Short Brothers, Limited, Pallion, Sunderland, for The Strick Line Limited, London. Main dimensions: 440 ft. by 57 ft. by 36 ft. 10 in. to shelter deck; deadweight capacity, about 9,000 tons on a draught of 25 ft. 1½ in. Triple-expansion engines of reheat type, with three oil-burning boilers, producing a speed of 12 knots in service, installed by Messrs. George Clark (1938), Limited, Southwick Engine Works, Sunderland. Trial trip, June 3.

TAPER GRINDING.—The Adam Machine Tool Company, Limited, Acme Works, Waverley-road, St. Albans, have introduced an instrument to facilitate the setting of grinding machines for taper grinding. It consists principally of a dial gauge and slip gauges which are used in the manner of a sine-bar. A chart for determining the length of the slip gauge to use is provided.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Copper for Electrical Purposes.—Three new specifications concerning copper for electrical purposes have recently been issued. They are B.S. No. 1432, covering sheet and strip; No. 1433, dealing with bar and rod; and No. 1434, relating to commutator bars. The new publications supersede four existing specifications, namely, B.S. No. 444, for plain, dead-soft copper strip, bars and rods for the windings of electrical machines; No. 445, dealing with copper commutator bars for electrical purposes; No. 518, for medium-hard copper strip, bars and rods for electrical purposes, and No. 1110, for hard copper sheet and strip for electrical purposes. The new specifications have been rearranged in a more logical sequence, each form of material being included in a separate publication. The scope of the specifications has also been modified so that the definitions conform to those recently published in B.S. No. 1420, which constitute the British Standard definitions for wrought products. The three new specifications contain requirements concerning the quality of the material and its finish, dimensional tolerances, tensile properties and electrical resistance. A table of temperature coefficients of resistance is also included in all the publications. [Price 2*s.* each, postage included.]

Earthing Clamps.—A specification for earthing clamps was originally issued in 1938 and this has now been revised as a result of extensive work by the British Electrical and Allied Industries Research Association. The clamps or clips involved are intended for connecting the earthing leads and earth-continuity conductors of electrical installations to metal pipes having a nominal internal diameter of up to 3 in. (corresponding to an external diameter of up to 3¾ in.) and also to the sheaths of lead-covered cables. The material to be used in the manufacture of the clamp was not specified in the original edition and it is now stipulated that the clamps, fixing screws and nuts shall be made of a non-ferrous metal; they may either be tinned or left untinned. [Price 2*s.* 6*d.*, postage included.]

BOOKS RECEIVED.

Ministry of Transport. Railways Division. Railway Accidents. Report on the Accident Which Occurred on the 10th December, 1947, at Manchester (Victoria) on the London, Midland and Scottish Railway. [Price 1*s.* net.] *Report on the Derailment Which Occurred on the 26th October, 1947, at Goswick on the London and North Eastern Railway.* [Price 2*s.* net.] H.M. Stationery Office, Kingsway, London, W.C.2.

Ministry of Supply. Dimensional Analysis of Engineering Designs. Volume I. *Components.* Part I. Prepared by Inter-Services Committee for Dimensioning and Tolerancing of Drawings. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 7*s.* 6*d.* net.]

Ministry of Supply. Scientific and Technical Memorandum. No. 3/47. *The Sealing Mechanism of Flexible Packings.* By C. M. WHITE and D. F. DENNY. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 10*s.* 6*d.* net.]

Department of Scientific and Industrial Research and Admiralty. Radio Research. Special Report No. 17. *Fundamental Principles of Ionospheric Transmission. Produced by the Inter-Service Ionosphere Bureau.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

The Manchester Joint Research Council. Communication Series No. 4. *Market Research. Report of the Conference Held on 22nd October, 1947, at the Albert Hall, Manchester.* The Manchester Joint Research Council, Manchester Chamber of Commerce, Ship Canal House, King-street, Manchester, 2. [Price 2*s.* 6*d.* net.]

Index to the Transactions of the Institution of Naval Architects. Volumes 47 to 88. 1905–1946. Offices of the Institution, 10, Upper Belgrave-street, London, S.W.1, and Henry Sotheran Limited, 2, Sackville-street, London, W.1. [Price 10*s.* net to Members of the Institution; 15*s.* net to others.]

The Colliery Year Book and Coal Trades Directory, 1948. The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 25*s.* net.]

Highway Bridge Design. By DAVID Y. HILL. Charles Griffin and Company, Limited, 42, Drury-lane, London, W.C.2. [Price 42*s.* net.]

Protective Methods for A.C. Power Circuits and Machines. By H. M. MARKLEW and J. A. COLLIER. Blackie and Son, Limited, 66, Chandos-place, London, W.C.2. [Price 10*s.* net.]

An Introduction to Metallic Corrosion. By DR. ULICK R. EVANS. Edward Arnold and Company, 41 and 43, Maddox-street, London, W.1. [Price 12*s.* 6*d.* net.]

PERSONAL.

SIR EDWARD APPLETON, F.R.S., has been appointed chairman of a scientific advisory committee to advise the British Broadcasting Corporation on radio research and its correlation with external activities in the same field. SIR JOHN COCKCROFT, F.R.S., is the vice-chairman and the other members are DR. H. J. BOOKER, PROFESSOR WILLIS JACKSON, D.Sc., DR. R. L. SMITH-ROSE, and PROFESSOR F. C. WILLIAMS.

PROFESSOR D. M. NEWITT, M.C., F.R.S., Professor of Chemical Engineering, Imperial College of Science and Technology, London, S.W.7, has been appointed a member of the Chemistry Research Board of the Department of Scientific and Industrial Research for a period of four years.

At the annual general meeting of the Institution of Structural Engineers, 11, Upper Belgrave-street, London, S.W.1, held on May 27, MR. L. SCOTT WHITE, M.I.C.E., was elected President for the 1948-49 session. The vice-presidents elected were PROFESSOR R. H. EVANS, D.Sc., M.I.C.E., MR. E. GRANTER, B.Sc., M.I.C.E., LT.-COL. E. J. HAMLIN, D.Sc., M.I.C.E., MR. G. M. MCLAREN, MR. J. E. SWINDLEHURST, M.A., M.I.C.E., and MR. L. TURNER, B.Sc., M.I.C.E. The honorary treasurer is MR. S. B. HAMILTON, M.Sc., A.M.I.C.E., and the honorary secretary, MR. W. C. ANDREWS, O.B.E., M.I.C.E.

MR. PETER WRIGHTSON, O.B.E., second son of SIR T. G. WRIGHTSON, Bt., chairman of Messrs. Head, Wrightson and Company, Limited, Thornaby-on-Tees, has been elected a director of the company, in succession to MR. W. I. WRIGHTSON who retired last year.

MR. P. WARDROBE, chairman of Messrs. Wardrobe and Smith, Limited, Arley-street, Sheffield, was elected President of the Crucible Steel Makers' Association, on June 7, in succession to MR. P. B. HENSHAW, joint managing director of Messrs. Kayser, Ellison and Company, Limited, Sheffield, who has retired after occupying the office of President for three years.

LT.-COL. G. W. P. DAWES, D.S.O., A.F.C., who has been district secretary of the Federation of British Industries at Nottingham for 19 years, has now retired. He is succeeded by MR. K. J. WEBB, D.S.C., who has been assistant secretary in the Cambridge office of the Federation since 1947.

MR. R. G. BRANDON has been appointed general sales manager, lamp and lighting department, the British Thomson-Houston Company, Limited, as from June 1.

MR. C. E. EDWARDS has been appointed sales manager of the Appleby-Frodingham branch of the United Steel Companies, Limited, 17, Westbourne-road, Sheffield, 10.

MR. E. R. BROWN, hitherto assistant works superintendent, locomotive works, London Midland Region, British Railways, Horwich, has been made assistant works manager, Crewe Locomotive Works. His place as assistant works superintendent at Horwich is to be taken by MR. J. SINCLAIR.

The telephone number of the head office and London sales office of the NORTHERN ALUMINIUM COMPANY, LIMITED, Wellington House, 125, Strand, London, W.C.2, has been changed to TEMple Bar 8430.

THE ALUMINIUM WIRE AND CABLE COMPANY, LIMITED, 10, Buckingham-place, London, S.W.1, have now transferred to their works at Swansea the manufacturing facilities for aluminium and alloy wire and hot-rolled rod previously operated by the BRITISH ALUMINIUM COMPANY, LIMITED, and REYNOLDS LIGHT ALLOYS LIMITED.

MESSRS. PEARSON PHILLIPS LIMITED, 194-196, Finchley-road, London, N.W.3, have been appointed sole distributors for L. Schuler A.G., Goeppingen, Wuerttemberg, United States Zone, Germany.

MESSRS. W. EDWARDS AND COMPANY (LONDON), LIMITED, Kangley Bridge-road, Lower Sydenham, London, S.E.26, have been appointed sole United Kingdom export agents for the new "Flamemaster" hand torch for all applications where small and medium-sized flames are used, by the manufacturers MESSRS. CHANCE BROTHERS, LIMITED, Lighthouse Works, Smethwick, 40, near Birmingham.

ENGINEERING CENTRE, GLASGOW.—The readiness of Scandinavian countries to import engineering equipment from this country was referred to by Mr. G. Gordon Jackson, managing director of the Engineering Centre, 351, Sauchiehall-street, Glasgow, C.3, when reporting on his recent visit to Norway, Sweden and Finland. He expected Scandinavian visitors to come to the Centre during the summer. An interesting form of heating has been employed in the coffee lounge at the Centre. Dulrae low-temperature electrical heating panels, supplied by Messrs. Richard Crittall and Company, Limited, have been installed in the lower part of the walls. They are completely hidden, and are insulated against heat losses through the walls. A composite wallboard-veneer panel has been developed for the surfaces of the walls. Messrs. Wylie and Lochhead furnished the lounge as an example of ship's furnishing, and are responsible for the heating system.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Production is being well maintained at the steelworks, but makers are still unable to raise their outputs to the full capacity owing to the difficulty in securing the metal necessary for the furnace charges. Local scrap collections are being made, but deliveries are only sufficient to meet the daily throughputs at the works. Some improvement in imported tonnages is needed; otherwise even the present modified rate of production will be difficult to maintain. Local coke supplies and "imports" from the North of England are being continued at recent levels, but there is still a shortage at the blast-furnaces which prevents the attainment of maximum outputs of pig-iron, which might have helped to eke out the scrap tonnages. Extensive alterations and improvements at Stewarts and Lloyds' Tube Works are well in hand, and plans are advanced for a second tube mill at Clydesdale and for a new tube mill at Tollcross. There is a heavy demand in the home market for steel products of all kinds, while the number of inquiries in the export section shows no sign of diminishing. Trade agreements negotiated by the United Kingdom are calling for a substantial tonnage of plates, sections, bars, and sheets from Scottish makers and rerollers for delivery in Period 2. Import licences have been rather more readily granted of late. Tubemakers are still fully employed. Last year, Stewarts and Lloyds delivered 72,000 tons of tubes for export, and it is expected that that figure will be exceeded this year.

Scottish Coal.—Conditions have been fairly quiet in Ayrshire and Lanarkshire following the Coal Board's handling of the unofficial strikes at Auchincruive and Priory Collieries. Both pits have been working steadily since, while stoppages elsewhere have been mainly of a minor character. Losses incurred by the strikes were offset by increased outputs in Lanarkshire, Fife, and the Lothians, and for the week, production totalled 473,000 tons, compared with 468,300 tons in the previous week. This is sufficient to meet the stipulated needs, and users are laying down reserve stocks. Deliveries are generally satisfactory in quantity, but industry is still anxious to secure increased tonnages of graded fuel. Moderate consumption needs are assisting electric power stations, gasworks, and other public-utility undertakings to build up stocks. Steelworks are much better situated for coal than they were a year ago, despite the higher steel outputs, while deliveries of coking coal are adequate to meet maximum throughputs at the coke-ovens. Some improvement in round coal supplies has augmented railway and domestic deliveries. Fairly active conditions prevail in the export trade, and some 20,000 tons a week are being shipped from Scottish ports. At present, Sweden and Finland provide the main outlets, with Denmark, France, and other European countries participating to a smaller extent. A small tonnage of anthracite beans has been under negotiation for Holland, but large anthracite is still not plentiful.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The production of local brands of pig-iron is being well maintained, and there is a steady flow of hematite iron into the works. Some steelmakers have been able to secure more iron and steel scrap, the supply of which needs to be increased considerably. The production of steel is being steadily maintained, but there is still a greater demand for slabs and billets than makers can meet. This is particularly the case in high-carbon steels, the demand for which imposes a heavy strain on rolling mills and forges producing sheets and bars for the agricultural and other steel trades. Well-filled order books at tool factories provide continuous employment as far as the supply of particular types of steel will permit; fork steel in the edge-tool trades is in particularly short supply. Makers of engineers' small tools are extremely busy and are securing many additional orders, except from some foreign markets affected by import regulations. Import restrictions also have caused stocks originally destined for export to accumulate in cutlery warehouses. Colliery-engineering firms are striving to give larger deliveries of mining equipment, including steel props and arches, wheels, conveyors and screening equipment. Good progress is being made with the manufacture of excavators and other equipment employed in the practice of opencast mining.

South Yorkshire Coal.—The production of coal is recovering from the rather low ebb reached as a result of unofficial strikes and absenteeism. Industrial steams are in request for stock, and there is pressure for locomotive hards and coking coal the supply of which has been inadequate for a long time. Efforts are being made to increase the supply of coal to Hull and Immingham where vessels are loading Midlands coal for shipment abroad. House coal is quiet. Gas coal is in strong demand for current use and for stock. Patent fuel is active.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—South Wales miners have submitted resolutions for consideration at the annual conference of the National Union of Mineworkers suggesting a review of the Coal Board's administrative machinery so as to give more power of decision at divisional and colliery level. They also advocated a greater measure of miners' control in the organisation and direction of the industry. Export business has been difficult to arrange on the Welsh steam-coal market throughout the past week owing to the shortage of supplies. Nevertheless, there were signs that some overseas consumers were dissatisfied with the present method of trading and were anxious to make arrangements for deliveries over a long period ahead. In addition, other foreign users, who have had to be content with what coal has been available from time to time, were desirous of exercising more choice in their buying, and wanted better-grade coals. Trade with Spain, which was recently resumed after being at a standstill since very early in the war, is quietly expanding. Prospects are also considered good for the development of the Brazilian trade. In pre-war years both these countries took very considerable quantities of Welsh coals. Of interest last week was the release of a cargo of 3,600 tons of Welsh anthracites for West Italy, the first to be sent to this destination for a long time. Shipments proceeded along steady lines for France, Portugal, Eire and the Argentine. Home requirements were heavy but the best grades and orders already in hand from the principal consumers were sufficient to ensure the steady lifting of these kinds for a long period to come. Cokes and patent fuel continued to attract a close attention, but supplies were difficult to secure.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, there was no appreciable change in business activity in tin-plate which remained somewhat quiet. The export market was also slow and the sales were much reduced, as makers, having well-filled order books for the current quarter, had little to sell. Steel sheets continue to be in demand, and fresh business, unless of high priority, is difficult to place. The demand for all descriptions of scrap has become urgent.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The aggregate tonnage output of iron and steel is being maintained at a high level but the demand still exceeds the distributable tonnage and customers at home and overseas are pressing for maximum deliveries of Tees-side products. Among the long-term problems of Middlesbrough's staple industry is the provision of ample supplies of iron ore. The yield of the Cleveland ironstone mines continues on a very disappointing scale and while imports of foreign ore are exceptionally heavy at present, a shortage towards the end of the year is likely. Consumers, therefore, are taking advantage of the opportunity to build up stocks of overseas high-grade ores. Iron and steel scrap is still in greater demand than merchants can supply; imports from Germany are much below expectations, but deliveries from home sources are substantial. The announcement of the Railway Executive of the conversion of 1,000 mineral wagons for the transport of coke to iron and steel plants is most welcome, as the Cleveland district will be one of the chief beneficiaries.

Foundry and Basic Iron.—Since the production of No. 3 Cleveland pig ceased some time ago, foundry-iron consumers have had to rely increasingly on deliveries from producing areas at a distance. Occasionally a Tees-side basic blast-furnace is turned over to make pig acceptable for foundry use but such tonnage production is meagre. North-East Coast ironfounders are now drawing their pig supplies almost wholly from the Midlands. The production of the basic blast furnaces is sufficient for the current needs of adjoining consuming plants, but provides no tonnage for other users.

Hematite, Low-Phosphorus and Refined Irons.—East-Coast hematite manufacturers are maintaining deliveries to customers of long standing who, however, continue to call for larger supplies. Outputs of low- and medium-phosphorus grades of iron are steadily taken up and the make of refined iron is rapidly absorbed as soon as it becomes available.

Manufactured Iron and Steel.—Semi-finished and finished iron and steel firms are assured of great activity during the third quarter of the year. Shortage of steel semies is appreciably less acute than it was but there is still a deficiency in the supply of the small sizes. Makers of semi-finished steel are providing users with increasing quantities of material and improvement in imports from Belgium has been of considerable assistance to re-rollers. There is no reduction in the heavy demand for sheets, plates, joists, sections and rails, and even the greater outputs now being attained do not permit larger allocations to non-priority customers.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—Tuesday, June 15, to Thursday, June 17, Royal Technical College, Glasgow, Summer Meeting. Tuesday, June 15, 10 a.m., Civic Welcome. 10.30 a.m., "Some Recent Advances in Mechanical Engineering on Shipboard," by Mr. T. A. Crowe. Afternoon, various alternative visits to works. 8 p.m., Civic Reception in the City Chambers. Wednesday, June 16, 10.30 a.m., Automobile Division paper on "Export Vehicle Design," by Mr. H. W. Fulton, followed by an afternoon works visit; or, various alternative whole-day fixtures. 7.45 p.m., Institution Dinner in the Grosvenor Restaurant, Gordon-street, Glasgow. Thursday, June 17, various alternative whole-day fixtures. 8 p.m., Conversazione, arranged by the Scottish Branch, at the Royal Technical College.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 16, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "The Operation of Ocean Weather Ships," by Captain C. E. N. Frankcom. (ii) Discussion on "Optical Properties of the Atmosphere," to be opened by Mr. James Paton.

INCORPORATED PLANT ENGINEERS.—*Western Centre:* Wednesday, June 16, 7.15 p.m., Grand Hotel, Bristol. "Factory Building," by Mr. E. O. James. *Liverpool Branch:* Thursday, June 17, 7.30 p.m., 9, The Temple, 24, Dale-street, Liverpool. Joint Meeting with the LIVERPOOL ENGINEERING SOCIETY. "The Elimination of Vibration," by Mr. R. B. Grey. *Leeds Branch:* Monday, June 28, 7.30 p.m., Mines Department, The University, Leeds. "Ball and Roller Bearings," by Mr. J. L. Potts.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Kent Branch:* Wednesday, June 16, 7.30 p.m., Royal Star Hotel, Maidstone. "Fluorescent Material and Colour Vision," by Mr. H. W. Windebank.

INSTITUTION OF MINING AND METALLURGY.—Thursday, June 17, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Impressions of Mining Practice in North America," by Mr. Jack Spalding.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Monday, June 21, to Wednesday, June 23, Burlington Hotel, Boscombe, Bournemouth. Summer Meeting. Monday, June 21, 8.30 p.m., Informal Reception. Tuesday, June 22, 10.15 a.m., "Heat Pump Principles and Applications," by Mr. J. H. Evans. 7 p.m., Reception and Banquet. Wednesday, June 23, whole-day coach tour.

CONTRACTS.

MESSRS. MIRRLEES, BICKERTON AND DAY, LIMITED, Stockport, are supplying three TLB6 six-cylinder oil engines rated at 289 b.h.p., at 500 r.p.m., coupled to 175-kW alternators for installation as auxiliaries in a passenger and cargo motorship which is being built by the TAIKOO DOCKYARD AND ENGINEERING COMPANY, LIMITED, Hongkong, for the China Navigation Company, Limited. The vessel will have a length between perpendiculars of 390 ft., a breadth moulded of 56 ft. 6 in., and a depth moulded of 33 ft.

MESSRS. THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, Duke's Court, 32, Duke-street, St. James's, London, S.W.1, and their associated companies, MESSRS. MIRRLEES, BICKERTON AND DAY LIMITED, and MESSRS. J. AND H. MCLAREN LIMITED—with whom, we understand, active merger negotiations are proceeding—announce that they have signed contracts to the value of two million sterling and are expecting to sign, within the next few days, further contracts valued at over one million sterling, for the supply to Russia of Diesel engines, Diesel-electric generating sets, and ancillary equipment. It is added that substantial deliveries have already been made under these contracts, a proportion of which is for equipment scheduled in the recent Anglo-Russian Trade Agreement.

THE LATE MR. A. T. GILLANDERS.—We note with regret the sudden death of Mr. Alexander Thomas Gillanders, which occurred at his home in Eltham, London, on May 25. Mr. Gillanders, who was 65 years of age, was for ten years power-cable manager of Standard Telephones and Cables Limited, until his retirement on August 1, 1942. He joined the Western Electric Company Limited (which later became Standard Telephones and Cables Limited) in 1902, and, starting in the cable contracts department, became power-cable manager 30 years later. During his retirement, Mr. Gillanders became a director of Southern United Telephone Cables Limited and the Union Cable Company Limited and was serving on their boards until his death.

75-MVA HYDROGEN-COOLED ALTERNATOR FOR LITTLEBROOK.

MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

(*For Description, see Page* 559.)

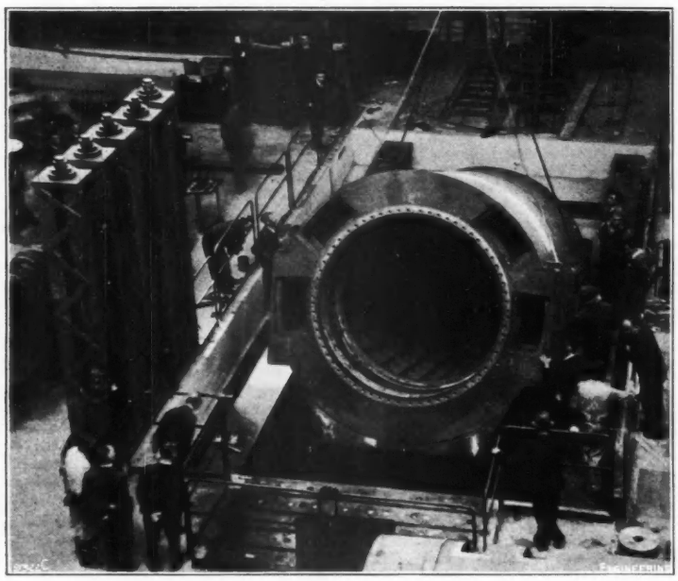


FIG. 4. STATOR BEING LOWERED ON TO TEST BED.

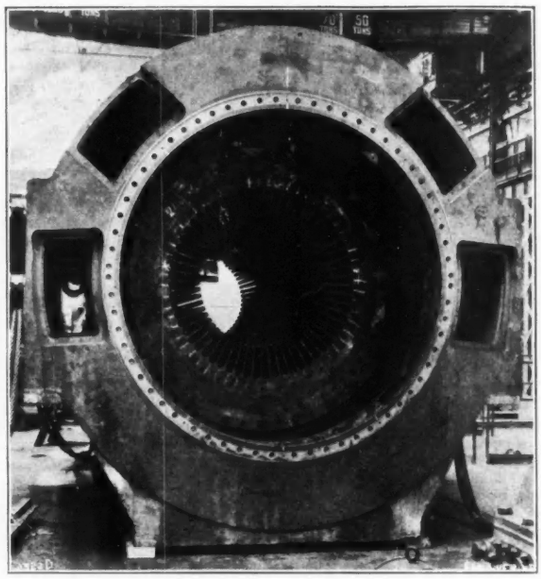


FIG. 5. END VIEW OF STATOR SHOWING HYDROGEN-COOLING DUCTS.

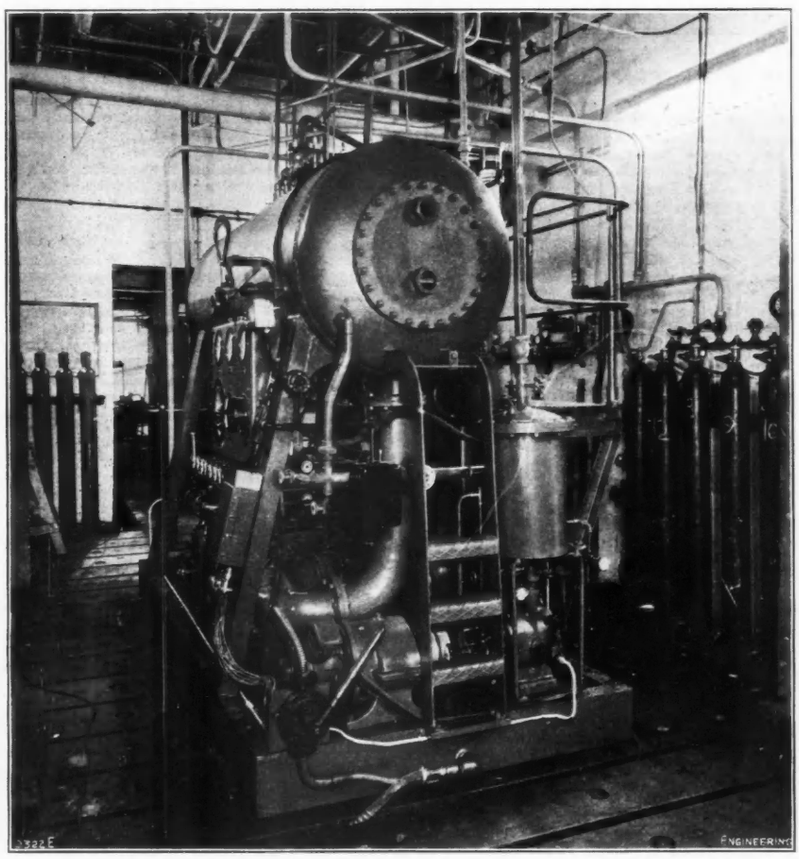


FIG. 6. CYLINDER CONTAINING VACUUM TANK, AND OIL AND AIR DETRAINING TANKS.

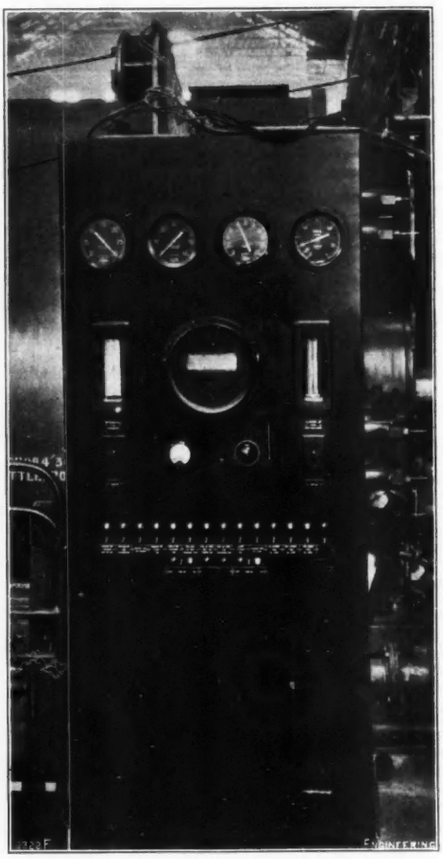


FIG. 7. CONTROL CABINET FOR HYDROGEN-COOLING SYSTEM.

EXHIBITION OF MACHINE TOOLS, BRISTOL.—Messrs. Alfred Herbert Limited, Coventry, have arranged to hold an exhibition of machine tools, measuring equipment and small tools at their Bristol office, 103, Whiteladies-road, Bristol, 8, from June 21 to 26, between the hours of 10 a.m. and 6 p.m. The machine tools on view will include lathes, milling, drilling, and grinding machines of various types, and the measuring instruments to be shown will include projectors, comparators and hardness-testing machines. Those interested in engineering production and inspection are invited to visit the exhibition.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, JUNE 11, 1948.

VOL. 165. No. 4298.

PIONEERS OF AMERICAN TELEGRAPHY.

THE general public, and the politicians whom they elect to positions of legislative and administrative power, are apt to greet scientific advances with unbalanced enthusiasm and to allow their imaginations to run far ahead of proximate possibility; the mechanical application of atomic energy and the jet-engine motor car, for example, are now popularly assumed to be just round the corner, despite all the cautious phraseology of the few who really know what they are talking about. This state of affairs did not always rule, and many of the important scientific and engineering developments which have now become woven into the web of everyday life were received at their inception with suspicion and even hostility. In many cases, reluctant acceptance, which ultimately developed into support, was due to some striking demonstration of practical utility. The story of the interest created by the service rendered in the capture of an escaping criminal by the first public electric telegraph line in this country, installed between Paddington Station and Slough in 1843, is well known. A corresponding incident in the United States took place in 1844 when, over a telegraph line extending from Washington to within 15 miles of Baltimore, a message was sent recording the nomination of Henry Clay for the presidency by the Whig National Convention held in the latter town. The message was delivered to Congress, sitting in Washington, an hour and a half before the train arrived from Baltimore bringing the same news. An achievement of this kind could be understood and appreciated.

In justice to Congress, it should be said that the telegraph line had been constructed with public money. Samuel Morse, who had been experimenting with telegraph apparatus for some eight years, and had tried to obtain financial support and official backing for his inventions in England, France and Russia, made application to Congress in 1842 for a Government grant to enable him to apply his apparatus on a commercial scale. He was successful, and a Bill appropriating 30,000 dollars for the construction of an experimental line between Washington and Baltimore was passed. Morse was by profession a portrait painter of considerable standing, and the Bill was apparently passed more in deference to him than "from confidence in his machine." Many Congressmen refrained from voting, "to avoid the responsibility of spending the public money for a machine they could not understand"; some British legislators, it may be remarked in passing, do not seem to experience this difficulty in voting for things they do not understand. This application to Congress was not the first which had been made in connection with the electric telegraph. An appropriation was recommended in 1838, at a time when the construction of a visual semaphore line from New York to New Orleans was being discussed. Although this first application was supported by Mr. F. O. J. Smith, the chairman of the House Committee on Commerce, it was not successful.

Morse was not working unaided in his attempts to develop the electric telegraph, although credit for devising the code, which will permanently link his name with this subject, must apparently go to him alone. In technical matters he received considerable assistance from Leonard Gale, professor of chemistry in New York University, and in the practical construction of apparatus from Alfred Vail, son of the proprietor of the Speedwell Iron Works, at Morristown, New Jersey. Various business men were also associated with his projects, these including F. O. J. Smith. The first experimental line was laid on the right of way between Baltimore and Washington of the Baltimore and Ohio Railroad, but the railway company apparently did not consider that the telegraph system was likely to be of any value in its service; it was to be removed without expense if it "should in any manner prove injurious." This failure to recognise that the electric telegraph would prove of great value in the operation of a railway long endured, and it was some ten years before the railway companies in the United States attempted to employ telegraphy for operational purposes. An entirely different state of affairs ruled in England and France, where railways were closely associated with the development of telegraphy from the beginning.

The Washington and Baltimore line, which was Government property, was at first operated by the Post Office Department with no financial success, and, in spite of the protests of the Postmaster General, who contended "that the public interest, as well as the safety of the citizen, requires the Government should get the exclusive control" of the telegraph, the existing line and the future development of the electric telegraph in the United States passed into private hands. By December, 1846, when the decision to abandon Government ownership and operation was taken, there were telegraph systems in service connecting New York and Boston, Buffalo, Philadelphia, Baltimore and Washington. Apart from the latter line, these had been constructed by private companies. From this time on, there was a feverish development of telegraph communication all over the country. Between 1846 and 1866, the capital of the operating companies increased from a few hundred thousand to more than 40 million dollars, and the length of their systems from a few hundred miles of line to more than 100,000.

An interesting account of this period of uncontrolled development and "methodless enthusiasm" is given in a recent volume* by Mr. Robert Luther Thompson, published by the Princeton University Press. This is a long, careful and detailed study, worthy of a great university, and its compilation must have involved the location and examination of an enormous mass of documents. Much of the history which is recorded is best typified by the author's phrase, "methodless enthusiasm," quoted above. Competition reduced profits to vanishing point; most companies were short of working capital; administration was loose and erratic, but

* *Wiring a Continent. The History of the Telegraph Industry in the United States*, 1832-1866. By Robert Luther Thompson. Princeton University Press, Princeton, New Jersey, U.S.A. [Price 7·50 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 42*s.* net.]

ultimately, out of the welter, various consolidations emerged and with the formation of the Western Union Telegraph Company, in 1866, at which year Mr. Thompson ends his narrative, some order was introduced into the field of telegraph operation. In the days of many competing small companies, much was done which comes but ill out of impartial financial scrutiny, but this feverish development with all its faults, losses and disappointments, did lead to the foundation of a nation-wide and invaluable service. It is doubtful if so extensive a system could have been built up in a rapidly-developing country on any other terms. No doubt, modern planners could point out much that was wrong in the methods pursued, but at least these were concerned with action, not merely debate; an "ordered" development would probably have found itself confronted in 1866 with a heap of what it is the present fashion to call "blue prints," rather than 100,000 miles of line.

The importance of the electric telegraph in the conduct of the affairs of the world is apt to be overlooked in the more spectacular triumphs of its competitor, the telephone. This, however, did not become of commercial importance until some 20 years or more after telegraph systems had been established and it is probable that, in the field of practical application, the experiences and disappointments endured by the telegraph companies were of great service to those concerned with the introduction of the telephone. Much practical experience was accumulated in the early days. Morse at first decided to lay the lines in pipes underground and, when overhead construction was adopted, much difficulty was found in insulating the wires from the poles. The first arrangement used, on the advice of Professor Joseph Henry, consisted of two glass plates, between which the wire was placed after being wrapped with cloth saturated with gum shellac; an arrangement invented by Ezra Cornell, Morse's mechanical assistant at that time. A form of bobbin insulator, which now appears an obvious form of construction, was, however, introduced at an early date.

The profound influence which the growth of telecommunication systems has had on the interrelation of the nations of the world is a publicist's commonplace, and although at the present time it appears to be doing more to divide the nations than to unite them, there is no doubt that the web of wires spreading across prairies and deserts and connecting every important centre of population was a main factor in building up the present great and united American nation. When Morse was labouring to bring his ideas to practical fruition, California was a distant province, little more than nominally associated with the Government at Washington; the telegraph made it an integral part of the nation. The possibilities and value of telegraphic communication between the Old and New Worlds were early recognised, and after the initial failure to lay an Atlantic cable in 1858, an ambitious project for connection with Europe via the Bering Strait and Russia was put in hand, though this was abandoned with the successful laying of the Atlantic cable in 1866. By this time the telegraph had become a powerful force for good or evil. Congress, which twenty years before, had washed its hands of the new means of communication, was now confronted with the problem of how to regulate this great force in the best interests of the people.

Of the many points of interest in the story of the early days of telegraphy in the United States, two in particular invite remark. One is the remarkably full extent to which it is documented, a fact that is self-evident from Mr. Thompson's book, but which is even more noticeable in the admirable two-volume biography of Morse by his son, Edward Lind Morse, which was published in 1914 and reviewed at considerable length on page 75 of our 100th volume (1915); almost a half of that work consisted of verbatim excerpts of the correspondence of Morse, his associates, and his opponents in his various controversies. The other point is the coincidence that so many minds should have been tending simultaneously in the same direction; even if Morse had failed in his pioneer work, there is little doubt that the advent of the electric telegraph would not have been long delayed.

SAFETY AT SEA.

IT is on record that when, in 1697, a French privateer destroyed the partly-built Eddystone lighthouse of Henry Winstanley, making prisoners of Winstanley and his workmen, Louis XIV immediately ordered that they should be released and returned to their own country, although a state of war then existed between England and France; for, he declared, the construction of the lighthouse was a benefit to humanity as a whole and should not be prevented. There could be no better example of the general attitude towards measures for promoting the safety of life at sea; and while, in the recent World War, Germany did not scruple to attack British light-vessels, the workings of the Teutonic mind are still exceptional and far from being proof of any widespread change of heart regarding maritime security. It would seem, indeed, that, just as the most diverse peoples and characters will unite in face of a common enemy, so there is a tacit agreement that, confronted by the forces of Nature, mankind should exhibit a community of purpose rising superior to the differences of opinion and principle that are held to justify open war. Certain it is that no common interest brings about a closer concord of action than that of ensuring, as far as may be reasonably practicable, the safety of those who "go down to the sea in ships and occupy their business in great waters."

Modern interest in this subject, never really dormant, was greatly stimulated by the loss of the White Star liner Republic in 1909 after collision with the Italian steamer Florida; thanks to the Republic's wireless, other vessels were summoned with such promptitude that popular opinion practically enforced the general adoption of this new safety device. The sinking of the Titanic, three years later, emphasised the wisdom of this development and also led to the demand for "boats for all"—though, in this respect, there was an obvious failure of the uninstructed to realise that the provision of boats is one thing, but the safe launching of them is another. From these and similar events, and the experiences of the 1914-18 war, there emerged the 1929 International Conference on Safety of Life at Sea, which laid down rules for general observance regarding the construction of passenger ships, life-saving equipment, wireless, navigation, and the issue of safety certificates. Other maritime disasters followed, however, the vulnerability of some large liners to fire being demonstrated with particular force, and various nations independently promulgated safety rules which went considerably beyond the standards established by the 1929 Conference. The need for a renewed uniformity having gradually become evident, another International Conference was convened and commenced its long series of sittings in London on April 23 of this year in the hall of the Institution of Civil Engineers.

The purpose of the 1948 Conference, in brief, was to examine the provisions of the 1929 Conference in the light of experience subsequently gained, especially in the war years, and of the advances made in scientific aids to navigation. Some 250 representatives participated, from more than 30 countries, and commenced their proceedings by electing Sir John Anderson, F.R.S., as President, and Admiral Joseph Farley, head of the United States delegation, as vice-president. It is likely that some considerable time will elapse before the full report is available, and there must be necessarily a further fairly long interval before it is ratified by the authorities of the participating nations. Some indication of the general trend of part, at least, of the deliberations may be gained, however, from certain new rules recently put into force in British ships by the Minister of Transport, under the powers already conferred upon him by the Merchant Shipping Acts. These rules which came into operation on May 20, are contained in S.R. and O. No. 1007 to 1012 of 1948, and are entitled "The Merchant Shipping (Lifesaving Appliances) Rules, 1948."

The changes in the rules regarding life-saving appliances are recommended as the result of a review, by the Life-saving Appliances Working Party appointed by the Ministry, of various war-time measures in this category. The main modifications, which now become peace-time practice, are that all seagoing ships of 150 ft. or more in length shall be fitted with mechanical davits; that davits in all seagoing passenger ships and foreign-going cargo ships shall have wire-rope falls and lowering winches; that the lifeboats in foreign-going ships (passenger and cargo) shall be not less than 24 ft. in length; that seagoing passenger ships, except short-voyage excursion ships, and foreign-going cargo ships shall carry a motor-boat; and that the radio equipment of foreign-going ships (passenger and cargo) shall include a portable lifeboat radio transmitter and receiver. Under the heading of "Fire Appliances," an important change is the inclusion of cargo ships in the category of those required to conform to the rules; before the war, there were no rules governing the provision of fire appliances in cargo ships, although, in fact, many owners had their own regulations and there can have been very few vessels of this type which could have been regarded as wholly lacking in effective protection against the more frequent fire hazards. The rules are also extended to cargo ships, in which there was previously no obligation to carry out such safety exercises.

On paper, these provisions are excellent, but—at the risk of being accused quite unjustifiably of a desire to take chances with the lives of seafaring men—we venture to suggest that they appear to typify a tendency to excessive complication which is not unknown in other spheres where Ministerial Orders have sprouted somewhat profusely in recent years. The technical officers of the Ministry of Transport are second to none in the corresponding departments of other countries and may be relied upon to keep the practical aspects always in mind; but the wording of these rules suggests that the practical suggestions of practical men have become overlaid with the verbosity natural to the legal mind, seeking to produce regulations that shall be as nearly universal in their application as can be contrived, and apt to lose sight of the fact that, in a nautical emergency, simplicity is almost as important as reliability. Wire falls may be, and doubtless are, greatly superior to hemp in many circumstances (though they require at least as much maintenance, and possibly more, if their efficiency is to be maintained); but a hemp fall can be cut with an axe or a knife, which cannot be done with wire. Mechanical boat-handling devices are admirable under favourable conditions, but they are liable to become clogged with frozen spray in winter and then are often more difficult to free than the simpler hand tackle; and many experienced seamen hold that they offer no material advantage when a ship is listing badly, with a heavy sea running. No doubt, these points have been considered, and may have been held to have lost much of their former force in view of the increasing average size of modern ships; with a specified minimum size of lifeboat, too, it may be thought that mechanical handling is a *sine qua non*, but there is room for further improvement before mechanical appliances can be regarded as comparable with hand gear in consistent dependability.

There is the further point, though it is perhaps of less significance in an emergency, that insistence on the provision of a considerable amount of additional and expensive equipment may be a handicap in ship operation unless, by international agreement, it is imposed on the ships of all nations alike: that is obviously a matter with which the International Conference must deal. The most hopeful prospect, of course, is that the general adoption of improved navigational aids and improved standards of ship design and construction will so reduce the risks hitherto regarded as inseparable from seafaring that the need for more elaborate life-saving equipment will gradually diminish, even to vanishing point, though this ultimate achievement can hardly be said to be in sight yet. Experience in other fields indicates that safety devices can be multiplied to the extent of defeating their own object, and, on the face of things, improvements in the structural strength and seaworthiness of ships, coupled with such measures as the proposed light load line advocated recently by the Navigators' and Engineer Officers' Union, would appear to offer more promise than further elaboration of the equipment which owners must supply and regulations to which masters and crews must conform.

NOTES.

BIRTHDAY HONOURS LIST.

THE Honours List, which was published yesterday on the occasion of the official celebration of H.M. The King's Birthday, contains the names of a number of engineers and scientific men. Knighthoods have been conferred upon Mr. Arthur Gouge, B.Sc., M.I.Mech.E., F.R.Ae.S., vice-chairman and chief executive, Saunders-Roe, Limited; Professor C. N. Hinshelwood, M.A., Sc.D., F.R.S., holder of Dr. Lee's Chair of Chemistry, University of Oxford; Mr. Ellis Hunter, deputy chairman and managing director, Dorman, Long and Company, Limited, and President of the British Iron and Steel Federation; and Mr. H. E. G. West, managing director, Newton, Chambers and Company, Limited. Vice-Admiral (E) D. C. Ford, C.B.E., Engineer-in-Chief of the Fleet, has been created a Knight Commander of the Order of the Bath, and Air Commodore Frank Whittle, C.B., C.B.E., M.A., M.I.Mech.E., F.R.Ae.S., F.R.S., a Knight Commander of the Order of the British Empire. The new Companions of the Order of the Bath include Mr. H. M. Garner, M.A., F.R.Ae.S., Principal Director, Scientific Research (Air), Ministry of Supply; and Mr. O. Thornycroft, O.B.E., B.A., M.I.Mech.E., F.R.Ae.S., Director, Aeronautical and Engineering Research, Admiralty. Among the new Commanders of the Order of the British Empire we note the names of Mr. H. W. Cremer, M.Sc., F.R.I.C., President of the Institution of Chemical Engineers; Mr. W. F. Higgins, O.B.E., Superintendent, Physics Division, National Physical Laboratory; and Mr. H. B. Robin Powell, A.F.C., D.L., M.I.N.A., chairman of directors, R. and W. Hawthorn, Leslie and Company, Limited.

THE NEWCOMEN SOCIETY.

As previously announced, the summer meeting of the Newcomen Society ("for the Study of the History of Engineering and Technology"—the history of their industry and profession is a closed book to so many engineers that it is still desirable to quote the full title occasionally) was held this year in King's Lynn and neighbourhood, under the presidency of Dr. A. P. Thurston, M.B.E., and attracted a record attendance. The members and their friends gathered on the evening of June 2, and though inclement weather prevented any immediate exploration of the historic town which was once the third port of the Kingdom, a Newcomen meeting never wants for a subject to discuss. In the course of the evening, the honorary secretary (Dr. H. W. Dickinson), announced that an invitation had been received from Holland to hold the 1949 summer meeting there; by show of hands, the members evidently welcomed the proposal. Thursday, June 3, was devoted to a motor-coach tour, in the morning to lavender works and stills at Fring, and a watermill at Heacham, by invitation of Mr. Linn Chilvers and Miss Chilvers; and in the afternoon, by permission of the National Trust, to the water mill owned by the Trust at Burnham Overy, which dates from 1795. In one of the mill buildings was seen a "whistle-ended" boiler, built by the Butterley Iron Works about 1832. It measured some 4 ft. 6 in. in diameter and 16 ft. in length, including the cut-away "whistle end" of about 4 ft., and formerly supplied steam to a Butterley beam engine. The engine was broken up after a life of about 50 years, but the boiler survived as a water tank. The excellence of the riveting was particularly notable. The remainder of the tour extended to Holkham, Wells-next-the-Sea, and Fakenham. In the evening, the annual dinner of the Society was held in King's Lynn and was followed by three short talks: by Mr. H. F. Hilton, M.A., on "The East Anglian Railway Company, 1846-62"; by Mr. Rex Wailes, M.I.Mech.E., on "Norfolk Wind and Water Mills"; and, finally, a survey of "West Norfolk Engineering," by Mr. Ronald H. Clark, A.M.I.Mech.E., author of the article on "Some Lesser-Known Traction Engines," which is concluded in this week's issue of ENGINEERING. The programme for Friday, June 4, comprised visits to the historic buildings of King's Lynn, under the guidance of Mr. A. L. Dorer, Lt.-Col. S. E. Glendinning, F.S.A., M.I.E.E., and Mr. Ronald Clark; an inspection of the civic regalia and archives, by courtesy of the Town Clerk, Mr. F. G. Reeves; and visits to the docks, where the party were received by Mr. Ivan J. Thatcher, A.M.I.C.E., the general manager, and inspected a horizontal duplex steam hydraulic pump, shortly to be removed, constructed by the late firm of Messrs. John Abbot and Company, Gateshead-on-Tyne; to the engineering works of Messrs. Savages, Limited, by courtesy of Mr. Stephenson Pilling; and to the timber yard of Messrs. Pattrick and Thompsons, Limited, by invitation of Mr. A. Roland Thompson. Messrs. Savages had arranged for the Society an exhibition of early drawings of agricultural and fairground machinery dating back to the early years of the firm, who celebrate their centenary in 1950. Messrs. Pattrick and Thompsons' plant included a beam engine, in steam, of unknown make, a horizontal engine by Messrs. T. W. Wedlake and Company, of Hornchurch, and a Marshall vertical engine, 7½-in. bore by 10 in. stroke, of about 1896, driving by belt a contemporary Gramme dynamo built by F. W. Dickinson, of St. Ann's Works, Leeds. The beam engine, which was transferred from a mill in Accrington in 1870, and is believed to date from about 1847, has a single cylinder 30¼ in. bore by 5 ft. 3 in. stroke, and gave about 100 indicated horse-power at 36 r.p.m. with steam at 30 lb. per square inch. The boiler, which was new in 1870, was supplied by Messrs. Savage and fired with shavings from the mill, the fireman using for the purpose a flat wooden shovel or "peel." The Wedlake engine, used for driving saws, had a single cylinder 15 in. bore by 24 in. stroke, and was notable for the ingenuity of its detail design, whereby one set of castings could be used to construct engines with either right-hand or left-hand rotation, and either unidirectional or reversing. The firm of Wedlake, it is understood, went out of business in 1947.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

The Annual Convention of the Incorporated Municipal Electrical Association opened at Eastbourne on Monday, June 7, and continues until to-day, Friday, June 11. Owing to the reorganisation of the electricity supply industry of the country on national lines this gathering is likely to be the last of a long series, although, it is hoped, it may be possible to continue some of the Association's activities. The formal proceedings began on Tuesday, June 8, when a meeting was held in the Winter Gardens, Devonshire Park. After a civic welcome had been extended to the Convention by the Mayor of Eastbourne (Councillor Randolph Richards, J.P.) the presidential address was delivered by Mr. J. Eccles. He said that the Association, like other kindred bodies, had ceased to exist, owing to the changes that had takpen place in the electricity supply industry. In an historical survey he pointed out that almost exactly 250 years ago Savery had invented the first practical steam engine. This substitution of steam power for manpower had been the first and greatest success of the industrial revolution. For at least 150 years from the date of Savery's invention, the country was without competitors in the mechanical field, so that by 1913 the whole world was in our debt. Two wars, however, had lost us our foreign investments and had greatly swollen the internal national debt. The problem with which we were now faced therefore was that of sustaining a weight of population which was created in a period of expansion when the whole world was clamouring for goods of which we were the main purveyors. To solve this problem, the main requirement was more manufactured goods of a quality and at a price that would induce the foreign customer to buy them. There were three ways in which this might be done: to get more manpower into the production line; to bring about more effective mechanisation; and to work a little harder. In the afternoon, a paper on "Gas Turbines for Public Electricity Supply" was read by Messrs. H. G. Bell and D. M. Smith, in which the design of this class of machine for that purpose and the particular fields in which it could be utilised were discussed. Wednesday, June 9, was devoted to whole-day excursions, while on Thursday, June 10, a further meeting was held in the Winter Gardens, when a paper on "Reorganisation for Efficiency on a Regional Basis" was read by Mr. R. C. Golding. The annual dinner took place in the evening, the principal guest being the Lord President of the Council (the Rt. Hon. Herbert Morrison, M.P.). To-day, the Convention is to be addressed by Lord Citrine, chairman of the British Electricity Authority.

THE MAUDSLAY SOCIETY.

The sixth annual meeting of the Maudslay Society was held at the Waldorf Hotel, London, W.C.2, on Friday, May 28, the chair being taken at the outset by the retiring President, Mr. H. Cecil Booth, M.I.C.E., who subsequently inducted his successor, Colonel C. F. Hitchins, D.S.O., M.I.Mech.E. The Society, which originated as an association of former pupils in the famous engineering works of Messrs. Maudslay, Sons and Field, of Lambeth, which closed down in 1900, has now as its main objective the endowment of a scholarship (or more than one, if funds eventually permit) in memory of Henry Maudslay, founder of the firm and virtually, by his introduction of the slide rest, of the modern machine-tool industry. The annual report presented by the retiring President stated that the Henry Maudslay Scholarship Foundation had been legally instituted during the year under review and that the funds accumulated had been handed over to the Charity Commission Official Trustees Department, the value of the capital at March 31, 1948, amounting to 2,563*l*. This will be considerably increased in the near future as further donations under covenant are received, especially that of the Maudslay Motor Company, who have undertaken to contribute £1,000 annually for seven years. Other promises of covenanted donations were received at the annual luncheon which followed the general meeting. In responding to the toast of "The Guests," proposed by Mr. J. Rennie Maudslay, Mr. F. Bray, representing the Minister of Education, expressed the appreciation of the Minister of the work undertaken by the Society. It was the Minister's wish, he said, to see a pioneering spirit behind technical education. The proposed Maudslay Scholarship was intended to be something more than merely a State scholarship; he hoped that it might take the form of a travelling scholarship, and that the winners might be, in a measure, ambassadors for the British engineering industry. The Ministry of Education would help towards that end in every way possible, because they felt that the need for such facilities was greater to-day than it had ever been.

TURN-ROUND OF SHIPPING IN UNITED-KINGDOM PORTS.

The report of the Working Party on the Turn-Round of Shipping in the United-Kingdom Ports was lodged in Parliament on Tuesday, June 8, and will be published in the course of the next few days. The Working Party was appointed on September 28, 1947, and their task was to consider measures likely to give speedy results in improved turn-round of shipping in United Kingdom ports and to initiate action or suggest methods by which improvement could be achieved. The importance of this subject was stressed by Mr. Alfred Barnes, Minister of Transport, at a Press conference held in London on Tuesday, June 8. Mr. Barnes pointed out that, at the beginning of the recent war, we had 16,900,000 gross tons of shipping, whereas now, despite the industry of our shipbuilders and the courage of our shipowners in ordering tonnage at the present high prices, we had only 15,700,000 gross tons. This meant that we had to charter, in dry-cargo ships alone, something like 2,000,000 tons deadweight. Mr. Barnes pointed out, however, that a saving of one day in the turn-round of each chartered ship would reduce the foreigu tonnage required by 30,000 tons deadweight. Furthermore, if this saving could be extended to cover all ships entering United-Kingdom ports, the foreign tonnage required would be reduced by 100,000 tons deadweight. The proposals put forward by the Working Party covered a wide field and included such items as the re-equipping of the ports, the use of mechanical-handling plant, the rebuilding of war-damaged transit sheds and warehouses, and the improvement in facilities for the dock workmen. Many of the proposals required consultation with other Government departments, while others required decisions

on capital expenditure and the allocation of materials. The general need for economy did not allow complete restoration of the ports and the introduction on a large scale of modern plant. Nevertheless, Mr. Barnes was confident that a better turn-round of ships could be achieved with the existing facilities and, with this object in view, he had made arrangements for copies of the report to be circulated to all ports and interested parties so that those recommendations which did not require capital expenditure could be implemented forthwith.

DIESEL ENGINE USERS ASSOCIATION.

The summer visit of the Diesel Engine Users Association this year, on Tuesday, June 8, was to the London County Council's Southern Outfall Pumping Station at Crossness, Kent. The party, in the charge of Mr. W. Howes, president of the Association, and Mr. H. Ferguson, secretary, travelled by steamer from Westminster to Crossness. At Crossness, the sewage from the L.C.C. southern area first flows into the station sandpits, where the heavier matter is retained. It then flows through vertical grills, and is pumped to culverts from which it gravitates to sedimentation channels where it remains for periods of about 100 hours. The channels are shut down in turn, the upper liquid being returned to the inlet and the sludge flushed to the sludge pumps. After further settling, the sludge is pumped to overhead tanks, from which it gravitates to vessels that deposit the material in the Thames Estuary. In the station there are two old steam-operated beam engine pumps. These engines are still serviceable and acted as stand-bys during the war years. The main pumping plant, however, consists of four triple-expansion steam engines, and four six-cylinder horizontally-opposed Diesel-engine operated pumps. Eventually, it is hoped to replace the steam engines by Diesels. At present, the Diesel engines are used normally, the steam plant being brought into service during heavy duty periods. The Diesel engines, which were built by the Brush Electrical Engineering Company, Limited, are of the four-stroke type; each runs at between 295 and 350 revolutions per minute and develops 460 to 590 brake horse-power. They have a cylinder diameter of 13¾ in. and a stroke of 20 in. Two vertical three-cylinder Crossley oil engines, each developing 300 brake horse-power, provide standby electrical power in the event of a failure of the mains supply. These engines, which have a cylinder diameter of 14½ in. and a stroke of 16½ in., operate at 375 r.p.m. They are coupled to three-phase generators, both of which have a continuous rating of 185 kVA at a power factor of 0·8.

INSTITUTION OF ELECTRONICS.—The third annual Electronics Exhibition, organised by the North-West of England section of the Institution of Electronics, will be held at the College of Technology, Manchester, on July 20, 21 and 22 It will be open from 2.30 to 9 p.m., on the first day, and from 10 a.m. to 9 p.m., on the two subsequent days. An exhibition of scientific films, arranged by the Manchester Scientific Film Society, will also be shown. Admission to the Exhibition is by ticket only and these may be obtained from Dr. J. A. Darbyshire, "Melandra," 1, Kershaw-road, Failsworth, Manchester.

THE LATE MR. C. P. SUTTHERY, O.B.E.—We regret to record the death of Mr. Colin Pellatt Sutthery, which occurred on June 1 after a short illness. Mr. Sutthery, who was manager of the merchandise and lamp sales department of the British Thomson-Houston Export Co., Ltd., was born at Springfield, near Chelmsford on August 13, 1887, and educated at King Edward VI's Grammar School, Chelmsford. After a year with the Hoffmann Ball Bearing Company, Limited, he spent five years as a pupil with Crompton and Company, Limited. Mr. Sutthery then joined the test department of the British Thomson-Houston Company, later transferring to the export department. After periods in Bulawayo and in Shanghai he returned to England in 1915. For his services on the staff of the Board of Inventions and Research, Admiralty, he was awarded the O.B.E. Early in 1919 he visited the United States and then opened an office for the British Thomson-Houston Company in Bombay, subsequently returning to London before going to South Africa as British Thomson-Houston representative. Mr. Sutthery returned to the firm's London office in 1931 and had since been in charge of the Company's export lamp and merchandise sales there. He was elected an associate member of the Institution of Electrical Engineers in 1932.

OBITUARY.

SIR ARTHUR SIDGREAVES, O.B.E.

NEWS of the sudden death of Sir Arthur Sidgreaves, which occurred as the result of a fall beneath an Underground train at Green Park Station, London, on June 7, will have come as a severe shock to a wide circle of his business and personal friends. Arthur Frederick Sidgreaves, who, until his retirement on March 31, 1946, was managing director of Messrs. Rolls-Royce Limited, was born at Singapore in June, 1882, and educated at Downside College, Bath. He entered the motor-car industry in 1902, when he commenced duties with Messrs. S. F. Edge, Limited, at that time the sole concessionaires for the sale of Napier cars. He remained with this firm until 1916 when he obtained a commission as Lieutenant in the Royal Naval Volunteer Reserve and was drafted to the White City, London, which was then the Royal Naval Air Service store for aircraft. He was officer in charge of the section dealing with aero-engines and spares, and was later promoted to the rank of Lieut.-Commander and subsequently, Major, R.A.F. For some months prior to the end of the war he was in charge of the production department, at the Air Ministry, dealing exclusively with Rolls-Royce aero-engines. He was made an O.B.E. in 1918.

Early in 1919, Mr. Sidgreaves returned to civil life and became assistant manager in the works of Messrs. D. Napier and Sons, Limited. He remained there until the summer of 1920 when he joined the staff of Messrs. Rolls-Royce Limited, as export manager. On the death of Mr. Claude Johnson, in 1926, he was appointed general sales manager and, in the autumn of 1928, general manager. In January, 1929, Mr. Sidgreaves was elected a director and was made managing director of the firm on the retirement, owing to ill health, of Mr. Basil Johnson on January 31, 1929. Under the direction of Mr. Sidgreaves the firm developed the liquid-cooled in-line Merlin engine which was employed in many of our famous fighters and heavy bombers during the recent war. In a statement issued by Messrs. Rolls-Royce on his retirement from the position of managing director on March 31, 1946, it was said that he had done "more than any other one man to deliver the tools with which the Royal Air Force . . . won the Battle of Britain." For his services to his country, a knighthood was conferred upon him in the New Year Honours, 1945. Sir Arthur also served on the boards of Bentley Motors (1931) Limited, Rotol Limited, Park Ward Limited, and Allied Motors Limited (India), from all of which he retired on March 31, 1946. He was elected President of the Society of British Aircraft Constructors in November, 1941, and held this office until October, 1943.

MR. SYDNEY SMITH.

WE note with regret also the death of Mr. Sidney Smith, which occurred at his home in Orpington, Kent, on May 30, after a period of failing health. Mr. Smith, who was managing director of the Wellman Smith Owen Engineering Corporation, Limited, Wilton-road, London, S.W.1, was born at Hitchin, Hertfordshire, on May 30, 1883. He received his general education at Harpenden, and, on June 15, 1898, began his apprenticeship with Messrs. Robey and Company, Limited, Lincoln, meanwhile continuing his technical education at Lincoln Technical College. On the completion of his pupilage, he remained in Messrs. Robey's drawing office until November, 1906. He then entered the drawing office and crane department of Messrs. Babcock and Wilcox, Limited, London, with whom he remained until December, 1908. After serving for some two years as leading draughtsman and outside erector to Messrs. Wellman, Seaver and Head, Limited, London, Mr. Smith went to Canada in August, 1910, to take up the position of assistant engineer to the Jeffrey Manufacturing Company, Montreal. In February, 1912, he became assistant contractor's engineer to Messrs. Mussens Limited, Montreal.

In March, 1913, Mr. Smith was appointed chief engineer to Jenckes Machine Company, Sherbrooke, Quebec Province, but gave up this position to return to this country in February, 1914, having been appointed engineer to the Whitehead Iron and Steel Company, Limited. He was responsible for the erection of some extensions to the works, but subsequently left to become engineer-in-charge of the Briton Ferry Steel Company, Limited, Briton Ferry, Glamorgan. For several years, Mr. Smith was responsible for the upkeep of these works and for maintaining their output. He relinquished this position in 1922 to join the staff of the Wellman Smith Owen Engineering Corporation which had been incorporated in 1919. At first he took charge of the firm's pulverised-fuel machinery section, but subsequently took over the management of the department responsible for the design and manufacture of seamless steel-tube machinery. He took a leading share in the development and perfection of the push-bench process in which work he collaborated with engineers on the staff of Stewarts and Lloyds Limited. After serving for some years as works manager of the Wellman Smith Owen Engineering Corporation, in London and at Darlaston, South Staffordshire, he was elected to the board, and, little more than 12 months ago, succeeded his brother, the late Mr. James Foster-Smith, M.I.Mech.E., as managing director of the firm. Mr. Sydney Smith was elected a member of the Institution of Mechanical Engineers in 1919 and of the Iron and Steel Institute in 1926.

BRITTLE FRACTURE IN MILD-STEEL PLATES—II.

(*Continued from page* 223.)

WE continue below our report of the Conference, on Brittle Fracture in Mild-Steel Plates, held at Cambridge, on October 26, 1945, by reprinting the contribution of Dr. C. F. Tipper on this subject.

DR. C. F. TIPPER'S PAPER.

Although mild steel is normally an extremely ductile material, there are numerous instances recorded where it broke with a crystalline fracture with little or no plastic deformation. The commonest examples of this are in connection with notched impact tests. One group of investigations employs bend tests; another centres round notch tensile tests. Both forms of test can be carried out at high or normal rates of loading. The factors which have been found to contribute most to low ductility in these tests are sharp notches, low temperatures, high rates of loading, and large dimensions of test-pieces.

Notches are made to give a high stress concentration of a complicated nature at the point of fracture. The presence of a notch in tensile tests has been found to increase the apparent strength of a metal at the expense of ductility. On the other hand, a notch is known to eliminate the upper yield point in iron and mild steel, and to lower the endurance limit in fatigue. There is a rapid fall in impact values at temperatures of from about 20 deg. C. down to — 50 deg. (70 deg. to — 60 deg. F.), according to the steel and its treatment. The rapid fall in impact value is not accompanied by a corresponding drop in elongation or increase in tenacity in a normal tensile test; this is more gradual. Embrittlement is attributed to precipitation effects of impurities, and steels from different sources are subject to these changes at different temperatures and to different extents. High rates of loading have been known to produce a brittle crystalline fracture in material which is ductile and breaks with a fibrous fracture when the same load is applied slowly. Large dimensions in notch bend tests and increase in width in impact tests have been found to change the fracture from a fibrous to a crystalline type. A decrease in ductility has been found in tests under combined stresses and, in some cases, differences in fracture stresses, which are not fully explained.

The most promising lines of attacking this problem thus seemed to be in the direction of high-speed notch tests at low temperatures. Confirmation in support of this conclusion came from an examination of some plates containing fractures. There was no sign of deformation in the plates, to which the paint was still adhering right up to the edge of the fracture. The surfaces had a characteristic "feathered"

BRITTLE FRACTURE IN MILD-STEEL PLATES.

TABLE I.—RESULTS OF TENSILE NOTCHED-BAR TESTS.

d.	b.	t.	A.	Y.	M.	Ty.	Tm.	El.	C.	Reduction in Area, Per cent.	No.
					Double-Notch Tests on ¼-in. Welding Shop Plate. (Notched on Faces t.)						
—	0·260	0·735	0–191	16·0	29·3	− 3·4	—	—*	0	—	W1
✱	0·760	0·735	0·466	18·3	32·4	+15·5	+16·2	15·8	30	—	W2
✱	1·50	0·735	1·01	16·5	30·7	− 1·7	+ 4·3	—	100	—	W3
					Double-Notch Tests on ½-in. Murex Plate. (Notched on Faces t.)						
—	1·00	0·507	0·507	17·1	30·4	—	—	35·0†	0	53·4	—
✱	0·4875	0·513	0·186	34·7	33·8	− 1·3	+ 1·3	6·5	100		MUR 1
✱	0·986	0·509	0·438	18·5	30·0	+15·7	+17·9	11·3	30		MUR 2
✱	2·00	0·509	0·955	18·7	28·6	− 1·7	+ 2·3	9·0	100		MUR 3
					Double-Notch Tests on S.D. 413, Place C, Average Thickness, 0·409 in. (Notched on Faces t.)						
—	0·986	0·409	0·404	17·0	26·5	16·4	—	37·5†	—	—	T.3
½	1·01	0·403	0·306	21·8	30·4	−17·4	−15·3	6·0	100	—	T.5
½	1·01	0·412	0·313	19·9	27·2	− 3·4	− 1·3	7·5	50	—	T.2
½	1·13	0·408	0·319	19·1	24·6	+14·5	+15·3	8·8	0	—	T.1
					Single-Notch Tests on ¾-in. Plate 2, S.S. Samzona. (Notched along Face t.)						
—	0·25 dia.		0·049	16·0	28·3	Temperature not controlled		21·0	—	69·4	—
½	0·762	0·622	0·397	19·2	29·1			21·0	—	—	1
					Single-Notch Tests on Plate E.B. (Notched along Face t.)						
—	3·0	0·25	0·75	20·3	28·4			52·3	0	—	—
✱	3·0	0·25	0·735	21·9	29·3	Temperature not controlled		19·6	0	—	—
✱	3·0	0·25	0·735	20·3	28·1			29·0	0	—	—
✱	3·0	0·25	0·735	20·5	28·0			22·3	0	Unbroken	—
½	3·0	0·375	1·08	21·3	27·5			19·6	0	—	—
½	3·0	0·25	0·719	22·2	32·5	− 6·8	− 2·1	27·5	0	—	—
½	3·0	0·25	0·719	21·6	29·5	+17·4	+19·2	26·3	0	—	—
					Single-Notch Tests on Plate 3, S.S. Samzona. Average Thickness, 0·339 in. (Notched along Face t.)						
—	1·001	0·339	0·339	20·6	32·2			25·0†	0	45·6	I
—	0·997	0·339	0·338	21·9	29·3	+ 0·9	+ 6·0	—*	0	—	II
✱	0·507	0·339	0·161	20·7	30·2	− 0·9	+ 6·0	9·0	100	—	30
✱	0·764	0·339	0·248	19·7	27·7	Cooled in ice water		22·0	10	—	29
✱	0·50	0·339	0·149	16·8	28·9			13·5	5	—	16
✱	0·50	0·339	0·149	18·2	26·1			14·0	5	—	17
✱	0·75	0·339	0·233	17·5	30·0			18·0	2	—	14
✱	0·75	0·339	0·233	20·4	29·0	Temperatur		14·5	5	—	15
✱	1·00	0·339	0·318	25·8	29·1	not controlled		8·0	—	—	I
✱	1·00	0·339	0·318	20·0	27·4			15·5	5	—	13
✱	1·024	0·339	0·326	19·6	26·3			9·0	2	—	3
✱	1·03	0·339	0·328	20·5	28·0			10·6	2	—	5
½	0·297	0·339	0·058	17·2	29·0				30	—	25
½	0·522	0·339	0·135	21·6	26·4	Cooled in ice water		2·5	100	—	24
½	0·764	0·339	0·217	21·3	25·0			3·5	100		23
½	1·00	0·339	0·298	23·2	27·3	Temperature not controlled		2·3	100	Polished	2
½	1·003	0·270	0·237	22·7	28·3			3·2	100	specimen	10
½	1·009	0·339	0·300	21·2	27·0	Cooled in ice water		4·5	100	—	28
½	1·015	0·339	0·302	19·9	25·9			11·5	5	—	22
½	1·02	0·339	0·303	21·1	26·3				5	—	7
½	1·025	0·339	0·305	20·0	24·3			10·0	5	—	4
½	1·04	0·339	0·311	21·9	25·8			8·0	5	—	6
½	1·75	0·339	0·551	17·1	22·3	Temperature		5·5	100	—	C
½	2·00	0·339	0·636	19·1	24·6	not controlled		4·2	100	—	8
½	3·000	0·339	0·976	19·3	24·3			5·0	100	—	9
½	3·022	0·339	0·982	18·4	25·0				2	—	26
✱	2·000	0·339	0·646	22·0	27·2			13·0	2	—	B
½	3·024	0·339	0·940	17·8	23·3				2	—	27
✱	2·75	0·339	0·859	23·0	24·4			2·3	100	—	A
—	1·001	0·339	0·339	20·6	32·2	—	—	25·0†	0	45·6	I
—	0·997	0·339	0·338	21·9	29·3	+ 0·9	+ 6·0	—*	0	—	II
✱	0·748	0·339	0·232	22·5	30·4	− 1·3	+ 6·0	9·0	100	—	43
✱	0·756	0·339	0·235	22·4	30·6	+ 1·3	+ 6·6	13·8	50	—	36
✱	0·760	0·339	0·215	22·5	28·7	+ 1·2	+ 4·6	3·0	100	—	33
✱	0·765	0·339	0·217	22·4	29·6	+22·5	+20·7	8·8	40	—	42
✱	0·770	0·339	0·219	26·5	29·4	+ 1·0	+ 3·2	2·0	100	—	34
✱	0·779	0·339	0·222	24·0	27·6	+13·2	+13·3	2·0	100	—	41
½	0·751	0·339	0·170	25·8	26·5	− 2·5	− 2·1	1·0	100	—	32
½	0·759	0·339	0·173	25·2	28·6	+10·0	+10·8	3·0	90	—	37
½	0·760	0·339	0·173	23·4	27·9	+14·5	+14·5	2·0	100	—	38
½	0·762	0·339	0·174	24·4	28·7	+23·7	+23·1	6·0	30	—	39
½	0·762	0·339	0·174	25·2	29·1	+34·5	+33·3	6·5	20	—	40
½	3·0	0·339	0·932	22·0	27·3	− 0·9	0·0	3·5	100	—	44
½	3·0	0·339	0·932	21·6	26·8	−15·7	−15·7	3·0	100	—	45
½	3·0	0·339	0·932	19·5	25·5	Temperature not controlled		8–14	5	—	II
					Single Notch Tests. (Notched along Face b.)						
—	1·001	0·339	0·339	20·6	32·8	—	—	25·0†	0	45·6	I
—	0·997	0·339	0·338	21·9	29·3	+ 0·9	+ 6·0	—*	0	—	II
✱	0·279	0·339	0·0773	21·1	27·8			7·8	10	—	20
✱	0·502	0·339	0·139	21·7	27·8	Temperature		8·3	10	—	21
✱	0·503	0·339	0·139	26·6	31·2	not controlled		4·0	100	—	D
✱	0·75	0·339	0·212	21·6	28·6			5·3	100	—	19
✱	1·00	0·339	0·278	23·1	30·2			5·5	100	—	12

* Broke outside gauge-length. † Elongation on 4-in. gauge-length.

d.	b.	t.	A.	Y.	M.	El.	Notched Face.	C.	Reduction in Area, Per cent.	No.
					Single-Notch Tests (except No. 7) on ¾-in. Plate E.R. 9826/1. (Temperature not Controlled)					
—	1·00	0·502	0·502	15·9	28·9	42·0	—	0	41·5	—
✱	0·862	0·240	0·153	20·4	29·0	6·5	*b*	0	—	B
✱	0·866	0·239	0·153	20·8	31·6	8·3	*b*	0	—	A
✱	1·019	0·861	0·814	16·3	27·4	6·0	*t*	100	Broke at flaw	4
✱	1·313	0·862	1·03	16·7	25·5	6·0	*t**	100	—	7*
½	1·022	0·861	0·781	16·9	25·6	4·6	*t*	100	—	3
½	1·032	0·861	0·781	17·0	27·5	6·3	*t*	95	—	1
2 mm. = 0·0788 in.	0·395	0·395	0·125	18·4	28·7	8·0	*t*	0	—	5
2 mm. = 0·0788 in.	0·395	0·395	0·125	18·7	29·3	10·5	*t*	0	—	6

* Double notch test.

appearance, but were so rusted that detail was unobtainable. Examination of the microstructure of sections through the fracture edge, and across a crack, showed that the path of the crack was transcrystalline. The presence of Neumann lines near the fracture in some plates indicated that these fractures formed under conditions resembling those of high-speed impact and shock. Further description and photographs of these features will be found in the second part of this report. It was decided, therefore, to try to reproduce these fractures under controlled conditions, using one of the forms of notched test-piece and beginning with the notch tensile test.

Previously, most of the work on tensile notched bars has been carried out on round bars having a circumferential notch. Round test-pieces cut from flat plate may give misleading results, owing to possible differences between centre and surface of plate. Moreover, the intention was to reproduce fractures resembling those found in actual cases of ship-plate failures, so it was particularly desirable to work with unmachined plate as far as possible. Sometimes it has been found necessary to use round machined test-pieces on account of shortage of material and limitations of testing facilities. Where this has been done, due allowance must be made when comparing the properties of the test-piece with those of the plate as a whole.

The following procedure was therefore adopted. Straight strips were milled from plates in widths varying from ½ in. up to 3 in. In these a notch was filed, or machined with a milling cutter. Later, two notches on opposite edges or faces were cut. Notch angles of 45 deg. and 60 deg., and $\frac{1}{32}$ in. up to ¼ in. deep, have been used. Fig. 43, on page 570, shows tracings made on the screen of the Hilger projector of notches of 45 deg. made by a milling cutter. The bottoms of the notches are not sharp and it may be assumed that the shape did not alter considerably across the strip. Details of dimensions of test-pieces and notches will be found in Table I, on this page. The strips were pulled in tension, using ordinary wedge grips. Dividers were set on gauge marks at equal distances on either side of the notch to determine the yield point. In all the later tests, the temperature was measured by means of a thermo-couple attached to the test-piece. Particulars of the plates will be found in Table II, on page 750.

It is only necessary to give a description of one test in detail. The following is typical of the sequence of events observed during a test.

Plate 3.—s.s. Samzona. Width of strip, 1¾ in.; thickness, 0·339 in.; notch on one side, 60 deg., ⅛ in. deep.

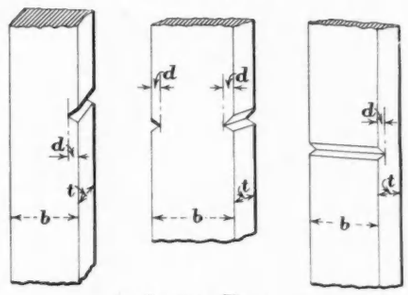
Load in tons :—

9·44 Yield point.

12·10 Crack visible in centre of notch. Load removed and reapplied up to 12·10 tons. No change. Test continued.

12·28 Crack opened up and fracture occurred with great suddenness. Fracture crystalline, straight across the strip at right angles to the plane of the strip and to the direction of pulling.

KEY DIAGRAM.

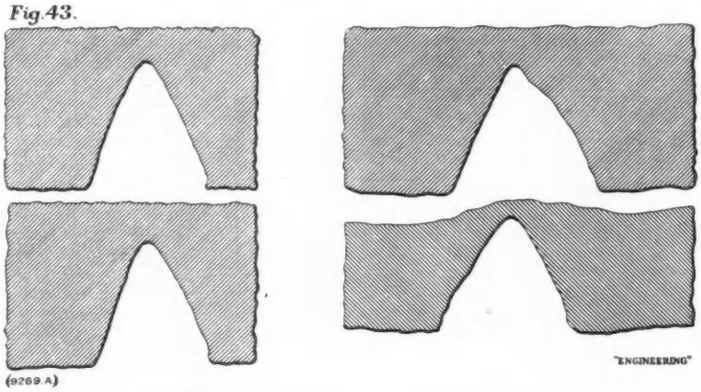


SYMBOLS USED.

b = breadth of specimen in inches.
t = thickness of specimen in inches.
d = depth of notch in inches.
A = notched area (*i.e.*, $[b - d] \times t$ or $[t - d] \times b$), in sq. in.
Y = yield stress in tons per square inch, calculated on area, A.
M = maximum stress in tons per square inch, calculated on area, A.
T *y* = temperature at yield in deg. C.
T *m* = temperature at fracture in deg. C.
El. = elongation per cent. after fracture, usually on a 2-in. gauge length.
C = approximate per centage of crystalline area in the fracture.

BRITTLE FRACTURE IN MILD-STEEL PLATES.

Fig. 43.



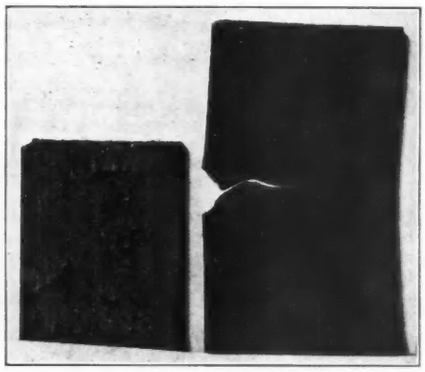


FIG. 45. ON LEFT: SIDE VIEW OF BRITTLE FRACTURE. PLATE 3. ON RIGHT: SIDE VIEW OF DUCTILE FRACTURE, E.B.

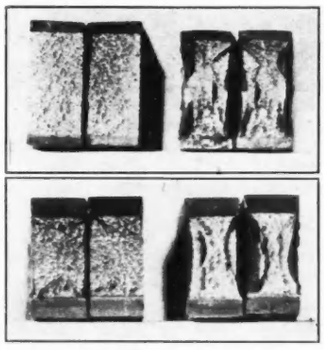


FIG. 47. PLATE 3.
No. 41. TY + 13·2 DEG. C. No. 42. + 22·5 DEG. C.
No. 37. + 10 DEG. C. No. 39. + 23·7 DEG. C.

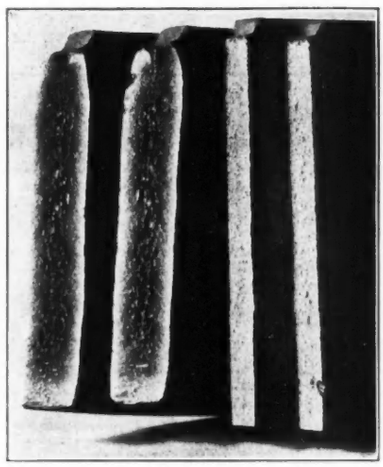


FIG. 44. ON LEFT: E.B. 375 × 3 IN. DUCTILE, FIBROUS FRACTURE. ON RIGHT: PLATE 3. 0·339 × 3 IN. No. 9. BRITTLE FRACTURE.

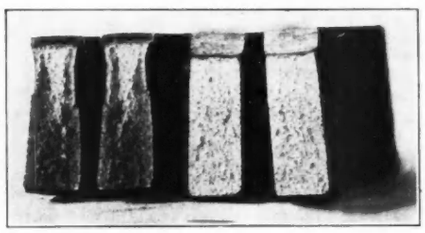
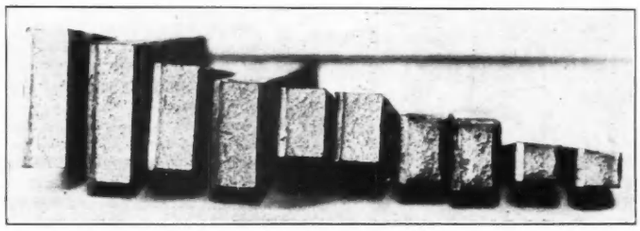


FIG. 46. PLATE 3. No. 5 ON LEFT: No. 2 ON RIGHT.



No. 12. No. 19. D. No. 21. No. 21.
FIG. 48. PLATE 3. NOTCH ON WIDE FACE.

TABLE II.—PARTICULARS OF PLATES.

——	1.	2.	3.	E.R.9826.	S.D.413.	E.B.	Mur.	W.
Analyses of Plates.								
C, per cent.	0·16	0·16	0·20	0·23	0·18	0·15	0·37	0·20
Si, ,,	0·04	0·03	0·02	0·01	0·05	0·254	0·048	0·06
Mn, ,,	0·35	0·53	0·38	0·36	0·33	0·71	0·45	0·51
S, ,,	0·021	0·025	0·034	0·027	0·040	0·034	0·026	0·036
P, ,,	0·009	0·014	0·038	0·017	0·022	0·044	0·012	0·041
Ni, ,,	Nil	Nil	Trace	Nil	Trace	0·05	Nil	Trace
Cu, ,,	0·04	Trace	0·10	0·12	0·20	—	—	0·15
Cr, ,,	Trace	Trace	0·10	Nil	Trace	0·01	—	Trace
Mo, ,,	Nil	Nil	Nil	Nil	Nil	—	—	Nil
W, ,,	Nil	Nil	Nil	Nil	Nil	—	—	Nil
V, ,,	Nil	Nil	Nil	Nil	—	—	—	—
Ti, ,,	Nil	Nil	Nil	Nil	—	—	—	Nil
Average thickness, in.	0·725	0·625	0·339	0·875	0·409	0·375	0·5	0·75
Tensile Test Results.								
Yield stress, tons per sq. in.	16·0	16·31*	20·6	15·9	17·0	20·3	17·1	16·0
Ultimate stress, tons per sq. in.	27·25	28·2	32·2	28·9	26·5	28·4	30·4	29·3
Elongation, per cent.	46·5	21·0	25·0	42·0	37·5	52·3	35·0	—
Reduction in area, per cent.	56·9	69·4	45·6	41·5	61·7	—	53·4	—
Izod Impact in ft. lb.	39, 40, 45	24, 50	15, 7† 9, 7	26, 29, 34	66, 61	90‡	—	28, 31, 27
Vickers Hardness Numbers.								
As received	115–120	127–130	125–144 (middle)	125–150	110–117	124	133–145	127
Normalised	114–118	134–128	145	129–134	—	—	—	130

* Round test-piece. † Under size test-pieces. ‡ Average of large number.

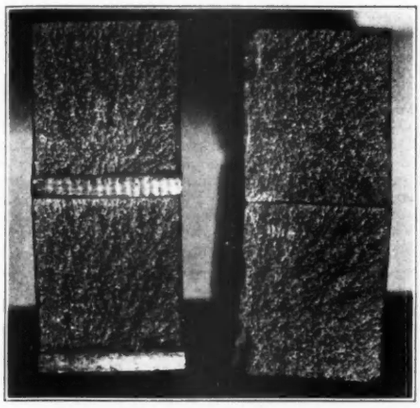
It will be noticed that there was quite a considerable interval between the yield point and the load at which a crack became visible. This was usual, but in most cases the rapidity with which the crack, once formed, opened up, made it difficult to obtain separate readings for either load or extension.

The values of yield stress and maximum stress given in Table I are calculated on the original area at the bottom of the notch. The elongation is calculated on gauge marks at equal distances on either side of the notch and therefore includes the fracture as well as the overall extension of the strip. With a few exceptions, the yield stresses of the notched strips are close to the value obtained for a normal test-piece. The low values were always associated with exceptionally bad laminations in the plate. On the other hand, the ultimate stresses vary considerably, the lower values being associated with low elongation figures and, therefore, extreme brittleness.

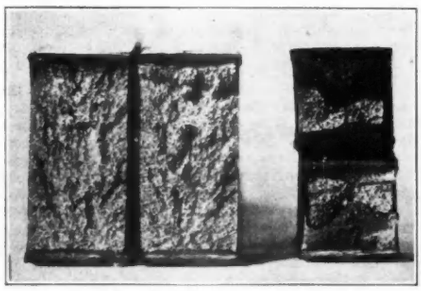
An attempt has been made to indicate the degree of brittleness in these tests by classifying fractures as 100 per cent. crystalline if there was no fibrous zone, and to estimate intermediate types of combined brittle and fibrous fractures approximately. It was observed, however, that, in cases of the most brittle fractures, there was always a small ductile zone at the bottom of the notch which was associated with a distinct reduction in thickness at the base of the notch. This fibrous region was generally so small in relation to the total area of fracture, unless the fractures were of the more generally fibrous type, that its presence may be neglected in classifying a fracture as brittle.

In some tests on Plate 3 from s.s. Samzona, and in certain other plates, the fractures started in a brittle manner, after the small fibrous zone referred to in the last paragraph, and then changed their character, becoming fibrous and silky, the plane of fracture also changing to one at 45 deg. to the axis. This type of fracture was associated with somewhat

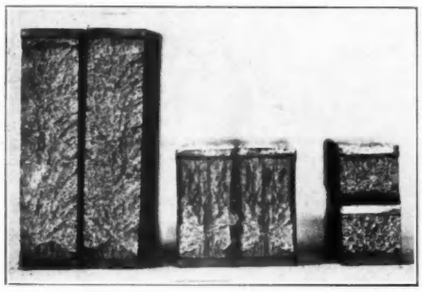
BRITTLE FRACTURE IN MILD-STEEL PLATES.



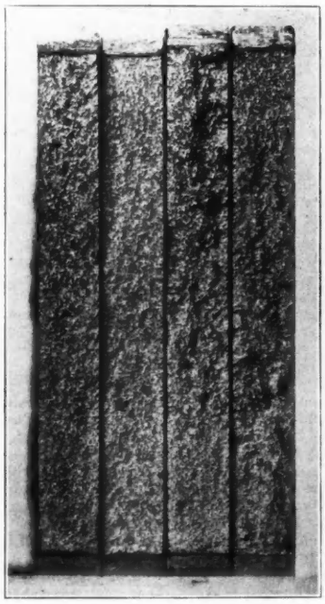
No. 4. No. 3.
(NOTE FLAW IN CORNER.)
FIG. 49. PLATE E.R. 9826/1.



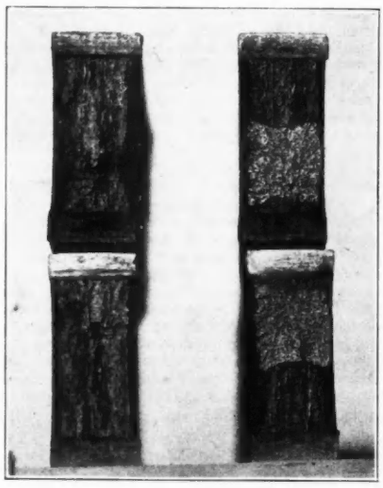
No. 3. No. 2.
TY. — 1·7 DEG. C. + 15·5 DEG. C.
FIG. 50. PLATE W.



No. 3. No. 2. No. 1.
TY. —1·7 DEG. C. +15·7 DEG. C. —1·3 DEG. C.
FIG. 51. MUREX PLATE.



No. 44. No. 45.
TY.—9 DEG. C. —15 DEG. C.
FIG. 52. PLATE 3.



T. 1. T. 2.
TY. 15·3 DEG. C. 1·3 DEG. C.
FIG. 53. S.D. 413 C.

Fig. 54.

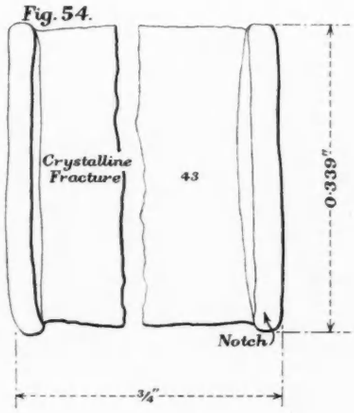


Fig. 55.

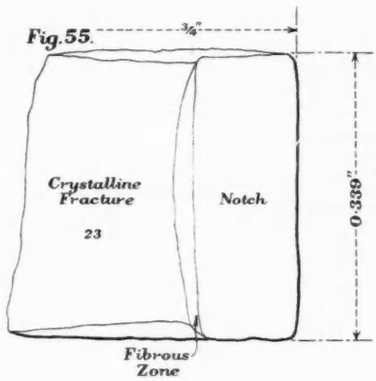
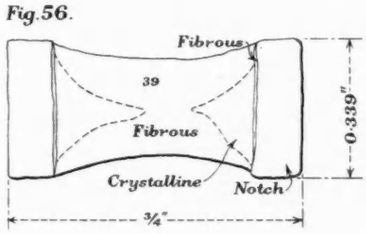


Fig. 56.



(9269.M.)

greater ductility. Some steels gave a fibrous fracture from the beginning. Figs. 44 to 53, on this and the opposite pages, illustrate the types obtained. Figs. 54, 55, and 56, on this page, are actual tracings of fractures made from the screen of the Hilger projector. Fibrous and crystalline zones are indicated. As might be expected, the depth of the notch and the width of specimen being tested had considerable influence on the fractures. The results were very erratic, however, even with test-pieces of the same dimensions from the same plate. The differences were variously attributed to non-uniformity of the plate, effect of direction of rolling, or the influence of the testing machine, differences in loading, etc., until these were proved in turn to have little effect.

The explanation came when it was found that brittle fractures were not obtained in warm weather, but that, as soon as the test-pieces were cooled in ice, then they failed with brittle crystalline fractures again. The variations found in the degree of ductility of the strips could be attributed, therefore, to the normal day-to-day temperature variations in the laboratory, and this was proved by carrying out a series of tests at different temperatures over the range of 0 deg. to 34 deg. C. (32 deg. to 94 deg. F.).

A copper-constantan thermocouple, used with a micro-ammeter, giving temperature readings of an accuracy of $\pm$ 0·1 deg. C., is now attached to every specimen pulled. The procedure adopted is to cool the steel to a temperature rather below that at which it is desired to carry out the test, and then to let it warm up gradually. Cooling may be done in ice water, a freezing mixture, or in solid carbon dioxide, and this is the most satisfactory. As the time taken to reach the yield point varies with the size of the test-piece, there are slight differences in the temperatures of testing in different tests. Beyond the yield point, the heat generated by the plastic deformation of the specimen makes temperature control difficult, so that, at the point of fracture, there may be considerable variation. This will depend on the rate and amount of extension, as well as on the dimensions of the test-piece and the temperature of the laboratory. The temperatures at the beginning and the end of the test have been recorded in Table I.

Most of the tests have been carried out with Plate 3, as a considerable amount of this plate was available; it had given brittle fractures and was of a suitable thickness. The change from a brittle fracture to a partly ductile one occurs in this plate between 14·5 deg. and 23 deg. C. (57 deg. and 73 deg. F.). A sufficient number of tests has not yet been done with other steels to fix the change-over point. So far, tests at 0 deg. C. and about 15 deg. C., —that is, normal room temperature—have usually been made. Some steels are not brittle at 0 deg. C. and still lower temperatures have to be used. This is in agreement with the observations of other workers. Lowering the temperature of Plate 3 to —15 deg. C. had no further effect on the fracture (Fig. 51).

(To be continued.)

ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS.—The annual dinner of the Association of British Chemical Manufacturers, 166, Piccadilly, London, W.1, will be held on Wednesday, October 13, at Grosvenor House, Park-lane, London, W.1.

SAMUEL OSBORN AND COMPANY'S APPRENTICE-TRAINING SCHEME.

PARTICULARS of the scheme for training apprentices adopted by Messrs. Samuel Osborn and Company, Limited, Clyde Steel Works, Sheffield, 3, are given in a brochure recently issued by the company. The scheme, it is pointed out, is administered by an advisory training committee consisting of two directors and five senior executive officers, and the actual training is planned and carried out by works committees consisting of managers, foremen and shop stewards. A full-time supervisor co-ordinates the training and looks after the progress of the boys. Entry to the scheme is normally at the school-leaving age, as fixed by the education authorities, but youths who are above that age are considered in special circumstances. Boys accepted are required to serve an "initiation period" of three months, during which they undertake a planned rota of junior duties in various departments of the works. These duties enable a boy to become acquainted with the various functions of the company, give him knowledge of the different departments and members of their staffs, and generally give him an insight into factory conditions. During this period, a boy is free to leave the company's employment; if, however, he is found satisfactory he passes on to the "probation period" of preliminary training and enters the trade for which he shows the greatest aptitude. During this period, the length of which normally does not exceed nine months, the boy is under the care of the apprentice-training supervisor, and note is taken of his progress, interest and keenness, particularly in his application to his trade; also of his conduct and time-keeping.

At the end of this period it is decided whether a boy is suitable for further training, and if so, and his parents or guardian are willing, he is invited to sign an agreement as an "Osborn Apprentice." He is then given a thorough training in his trade by selected skilled craftsmen and instructors. Practical training, coupled with lectures on workshop practice, is given in the works training departments, and theoretical training is provided by the Sheffield Education Committee. Normally, the period of apprenticeship is five years, ending at the age of 21. A craftsman's certificate is presented to the successful apprentice on completion of his training course. Awards are made during training, either in the form of a lump sum or as weekly additions to wages, for consistent attendance and achievement. An advanced post-apprentice training course is available for selected young men who have reached the School Certificate standard. This is intended to prepare them to fill positions on the supervisory staff.

The firm inform us that the apprentice scheme is working well. They state that at the present time there are 10 boys in the initiation stage, 24 in their probation period and 40 undergoing their apprenticeship course. Although these numbers fall short of the firm's requirements, the management are encouraged by the results so far achieved. They add that the boys show evidence of a keener interest in their work than has formerly been the case, and that this is coupled with a sense of discipline and a desire to improve their knowledge.

ROYAL SOCIETY SCIENTIFIC INFORMATION CONFERENCE.—A Conference on the Distribution of Scientific Information, organised by the Royal Society, will be held in London from June 21 until July 2. The conference will be attended by delegates from the British Dominions and Colonies, the United States and UNESCO, and all the plenary sessions will be held at the Royal Institution, Albemarle-street, London, W.1. The conference opens on the first day at 11.30 a.m., when Sir Robert Robinson, President of the Royal Society, will welcome the delegates. The matter to be discussed by the conference will be divided into four sections, dealing respectively with "The Publication and Distribution of Papers reporting Original Work" (Section I); "Abstracting Services" (Section II); "Indexing and other Library Services" (Section III); and "Reviews, Annual Reports, etc." (Section IV). The agenda for each section will be drawn up, and working parties appointed to consider the subjects, on June 21, 22 and 23. Meetings of the working parties will be held on June 24, 25 and 28, and these will be followed, on June 29, 30 and July 1, by plenary sessions of each section to consider and approve recommendations and make reports. On Friday morning, July 2, there will be a full session of the conference to approve the final form of the recommendations for submission to the Council of the Royal Society. The closing session of the conference will take place at 2.30 p.m. on July 2. An exhibition illustrating certain aspects of the subjects to be discussed at the conference is to be held in the rooms of the Royal Society from June 21 to 30. The secretary of the organising committee of the conference is Dr. D. C. Martin, assistant secretary, The Royal Society Burlington House, London, W.1.

LABOUR NOTES.

UNDER agreements negotiated by the National Association of Local Government Officers, about 15,000 "white collar" council employees in London are to have increases in wages in the form of larger "cost of living" bonuses. The changes are to have effect as from March 1. The bonuses for several grades in the London area are being raised by 10*l*. a year to 14*l*. a year, or 3*s*. 10d. a week to 5*s*. 4*d*. a week. Women over 26 years of age, in the clerical and higher clerical divisions, are to receive an extra 14*l*. a year—men 10*l*. a year. Town clerks, borough engineers, treasurers, and other high-ranking officials, are to have their own Whitley Council machinery for the first time, and the salary ceiling under the Local Government charter is to be raised to cover 1,000*l*. a year officials.

Addressing the annual meeting of the Federation of Textile Societies, Mr. J. H. Townson, the President, said that if nationalisation came to the textile industries, they should deserve it. Already, it was two centuries too late, for, in his view, it might have been put into practice when those great inventors, Crompton, Hargreaves, Kay and the rest, were "diddled" out of their miracles.

A pamphlet containing suggestions for attaining the all-round 10 per cent. increase in production requested by the Prime Minister was issued last week by the General Council of the Trades Union Congress to all affiliated unions. According to the pamphlet, there are few plants that cannot increase production by 10 per cent., or more, by stopping waste, and higher output does not necessarily call for harder manual work. Among examples of "waste" quoted are high turnover of labour in the year, bad factory layout, and too many "systems" employing large numbers of unproductive workers. It is suggested that efficient joint production committees could overcome most of these difficulties.

Addressing the annual conference of the Railway Clerks' Association last week, Mr. Percy Morris, M.P., the President, declared that the statement made by a delegate to the Labour Party Conference—that railwaymen had been "completely disillusioned about nationalisation"—was unfounded. As employees, they had never considered that nationalisation would immediately bring less work and more pay, and, so far as the public was concerned, from three to five years must elapse before any substantial benefit could be expected from the changes in management and administration.

The Union of Shop, Distributive and Allied Workers is at the head of a movement for the payment of wages throughout the country on Thursdays instead of Fridays, and is urging the General Council of the Trades Union Congress and a number of important Trades Councils to use their influence in support of the change. The housewife, it is claimed, would benefit by the change, as she would be able to shop on Friday morning or afternoon. It would also, it is officially believed, help the shop assistant by staggering the busy period. There could be then, it is argued, no reason for keeping open on Saturday afternoons.

The executive committee of the union has decided to embark, late this year, on a campaign for half-day closing on Saturdays, particularly in food shops. As a result of a ballot of shop assistants at Carlisle, the local authority is being asked to close all shops on Saturday afternoons. At Colchester, there is a movement to change market day from Saturday to mid-week.

In the course of his address to the Amalgamated Union of Operative Bakers at Margate last week, Mr. E. Haynes, of Birmingham, the President, said that it was frustrating to find the people's weekly wage deteriorating because of the continual rise in prices. There had been much talk, he continued, about the freezing of wages, but bakers did not accept the position and the executive was worried about the Chancellor's failure to deal with prices and profits in his recent budget. "Profits are," Mr. Haynes added, "on the highest level they have ever been in this country, and the T.U.C. has been urged to continue its efforts to get prices and profits reduced."

Officially compiled figures relating to the British coal-mining industry indicate that, in the week which ended on April 22, the output was 4,227,500 tons (provisional), compared with 3,151,100 tons in the previous week and 3,023,700 tons in approximately the same week of 1947. The total was made up of 3,957,700 tons of deep-mined coal and 279,800 tons of open-cast coal. The target for deep-mined coal is 4,000,000 tons a week. The loss of deep-mined tonnage through disputes, accidents, transport difficulties and other causes was 49,100 tons. There were no recognised holidays during the week. In the previous week—which included Whitsuntide—there was a loss of 808,100 tons under the heading of "recognised holidays." The total output of the year to date (21 weeks) is 85,069,300 tons, compared with 79,647,000 tons last year.

The Road Haulage Central Wages Board is seeking amendment to the existing Road Haulage Wages Order of January 9, 1948, proposing an increase from 9*s*. to 10*s*. 6*d*. in subsistence allowance, covering a period of rest away from the home depot not exceeding "fifteen hours" continuous duration. For an employee who is temporarily transferred for more than one week, it is proposed to increase the weekly subsistance allowance from 42*s*. to 45*s*. 6*d*. It is also proposed to make some special provision for milk employees.

The Ministry of Labour and National Service states that there were fewer strikes in this country last year than in 1946—they numbered 1,721 compared with 2,205—and 1,300 of them lasted no longer than three days. But the working days lost rose from 2,158,000 in 1946 to 2,433,000 last year. This increase was more than accounted for by coal mining (912,000 days in 1947, 216,600 days in 1946) and transport (628,000 in 1947 and 59,800 in 1946). The average number of days lost yearly in the fifteen years 1933 to 1947 was 1,890,000. The average for the fifteen years 1918 to 1932 was 26,080,000 per annum.

At its annual conference in London last week the Institution of Professional Civil Servants rejected a resolution urging affiliation with the T.U.C.

A temporary Act authorising the restriction of the use of labour in the Norwegian building industry, including road-making and similar projects, was passed on July 11, 1947. It went into effect immediately, and is to remain in force until December 31, 1949. Under the Act, the King may decide that without a special permit no building activity may be undertaken. Exceptions are provided in the case of (1) work projects in which fewer than four persons are simultaneously employed, unless regulations to the contrary have been passed, for certain areas and/or periods of time; (2) work projects falling within the employer's normal activity and carried out by his permanent staff of workmen; (3) work urgently required for the prevention or repair of damages, provided that not more than two weeks' time is involved. Employers engaging men contrary to the provisions of this Act are liable to a fine or imprisonment up to three months.

The 10th annual conference of the New Zealand Federation of Labour endorsed a report recommending extensive trade union amalgamations which will have the effect of reducing the number of unions in the Dominion from 400 to 13. The new grouping is to be on an industrial basis, but it is not intended that the members should be registered into new organisations against their will. They would be informed of the advantages to be gained by being united in larger and more effective unions organised on industrial lines.

On the recommendation of the conference, a new system of price control was adopted. In the future control of prices the financial position of each industry, it is stated, should be taken into account. Applications made for price increases in any given commodity should be preceded by an examination of the profits of the undertaking which is making the application in order to ascertain whether the undertaking could carry all or part of the increases.

The Second National Convention of Chilian Public Employees—which was held at Valparaiso last year—approved resolutions and recommendations on the following points: reform of the Public Employees' and Journalists' Fund, particularly regarding pensions, loans on security and life insurance; establishment of a consumers' co-operative society made up of the civilian personnel of Government departments; the need for re-organisation of the national medical service for salaried employees; the construction of a home for public employees; the nationalisation of sources of raw materials and of public-utility services; the revision of concessions to foreign capital; agrarian reform and improvement of the conditions of life of the rural population; preparation of a general housing plan; establishment of a State Bank which would aim at an effective increase in production; re-organisation of public administration and participation of technicians therein; revision of the taxation on the basis of fair distribution of public charges; and a sliding scale of salaries to counteract the rise in the prevailing cost of living.

WELDABILITY OF STEELS AND WELD-CRACKING TEST.

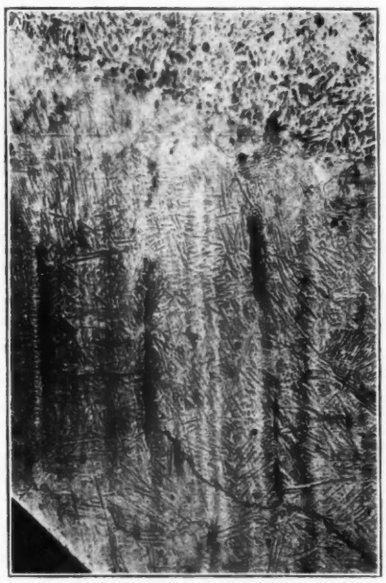


FIG. 1. CRACKS IN HEAT-AFFECTED ZONE OF WELDED LOW-ALLOY STEEL. × 100.

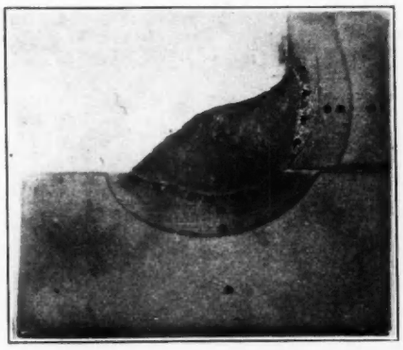


FIG. 2. SECTION FROM REEVE WELD-CRACKING TEST.

Fig. 3.

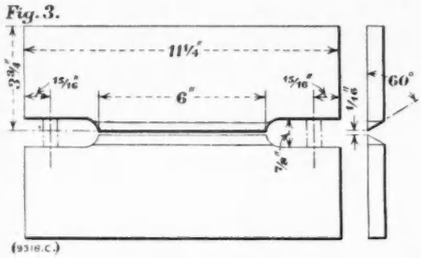


Fig. 4.

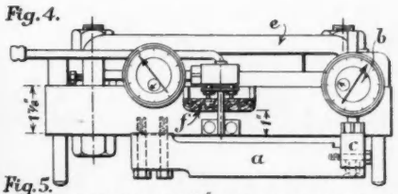
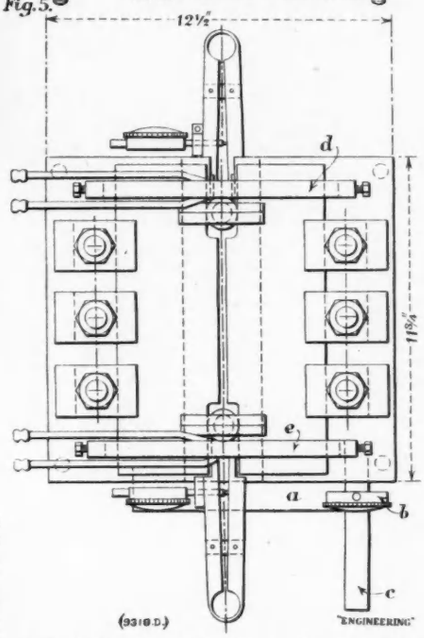


Fig. 5.



THE WELDABILITY OF STEELS, AND A NEW WELD-CRACKING TEST.*

By P. L. J. LEDER, M.Sc.

WHEN a steel is welded, it is subjected to a thermal cycle which produces certain important changes. In the first place, it causes locked-up stresses, due to the thermal expansion and contraction of both weld and parent metal, and in the second place it produces modifications in the metallurgical structure, and hence in the properties of the steel. In certain circumstances, a combination of these mechanical and metallurgical effects can lead to cracking and failure of the joint. Cracking in a welded joint may occur in three places, namely, the deposited weld metal, the interface between the weld deposit and the parent plate, or in the heat-affected area of the parent plate immediately adjacent to the weld. The paper is concerned with the last-named form of cracking, which is probably the most common of the three, and presents the most interesting metallurgical problems. The paper, furthermore, is concerned primarily with the weldability of high-tensile steels, but, in order fully to appreciate the factors involved, it will be necessary first to consider briefly the principles involved in the welding of mild steel and the low-alloy structural types of steel.

The weldability of a steel has been defined in various ways but, from the point of view of the paper, it can be taken to mean the resistance to cracking of the heat-affected material under given conditions of restraint. When a steel is welded, a temperature gradient is set up in the vicinity of the weld, ranging from a temperature above the melting point of the steel at the weld junction, or interface, to the initial temperature of the steel at a distance from the weld. A part of the heat-affected area, near the weld, is therefore heated above the hardening temperature of the steel, so that, on subsequent cooling, hardening takes place. In mild steel the hardening which takes place is insignificant, but in higher tensile steels, where owing to the higher alloy content the hardenability is greater, considerable increases in hardness may occur as a result of welding.

It was soon found that there was a close connection between the cracking behaviour of a steel and the hardness developed in the heat-affected zone, and a large amount of work has been done by many investigators, in studying the properties—in particular the hardness—of this zone, and correlating the results with the observed weldability of the steel. The actual mechanism of the cracking is still imperfectly understood, although generally it has been taken to be due to inherent weaknesses and incipient cracks in the martensite present in the hardened zone; the cracks propagate under the influence of the welding stresses. Typical cracks of this type are shown in Fig. 1, which also shows the manner in which they can be influenced by the presence of slag stringers in the steel.

The possibility that cracking in the heat-affected material was due to the volume changes associated with the transformation of austenite to martensite—occurring at a relatively low temperature at which the material would be unable to accommodate such a strain—was investigated by Rollason and Cottrell. They showed, however, that this was not the case, since the cracking occurred in the temperature range 40 deg. to 70 deg. C. (104 deg. to 158 deg. F.), the martensite transformation for the medium alloy steels investigated being initiated in the range 270 deg. to 210 deg. C. (518 deg. to 410 deg. F.). Accordingly, the maximum hardness developed in the heat-affected zone of the weld has been used by many investigators as a measure of the weldability of the parent material. In this country, for example, the R.11 Committee of the Institute of Welding showed that carbon-manganese steels could be welded safely under conditions of severe restraint without any danger of cracking, provided that the maximum hardness of the heat-affected material did not exceed diamond pyramid hardness No. 350, and numerous investigators, notably Dearden and O'Neill, showed that this criterion was applicable to a wide range of low-alloy structural steels.

The factors affecting the hardness developed in a heat-affected zone are, fundamentally, the composition of the steel and the cooling rate after welding. This cooling rate depends on the relative rates of heat input and heat dissipation, as controlled by the welding conditions, i.e., size of electrode, welding current, speed of welding, size and shape of joint, and so on. The faster this cooling rate after welding, the greater will be the tendency for a given steel to harden. It is therefore good policy to retard the rate of cooling after welding by such means as the use of large electrodes giving a relatively high heat input, or by pre- or post-heating of the joint. The R.11 Committee of the Institute of Welding, in fact, established minimum fillet sizes for the safe welding of various structural steels in different thicknesses.

So far as the composition of the steel is concerned, increasing carbon and alloy contents lower the critical cooling rate of the steel or, in other words, increase the probability of hardening occurring at the cooling rate produced by any given set of welding conditions. In addition, increases in the carbon content increase the hardness of the martensite produced. In selecting or developing a steel for welding, therefore, the carbon and alloy contents must be kept down so far as is consistent with the minimum mechanical properties required. The effects of composition and welding conditions on the maximum hardness likely to be induced in a steel, have been demonstrated experimentally by French and Armstrong, and various other investigators.

The weld hardenability of a steel can be estimated directly by depositing on it a bead of weld metal under controlled conditions and measuring the diamond pyramid hardness of the hardened zone so produced. A more academic practical method of estimating the hardenability of a steel directly is the well-known "end quench test" introduced by Jominy. This test is an essential feature of the Doan system referred to below. The use of weld hardness as a measure of weldability, however, is itself open to some objection. Although hardness certainly bears an inverse relation to weldability, it is not a complete measure of all the factors which determine weldability: anomalous results occur. For example, there have been cases of steels which have withstood severe welding tests despite the fact that they have developed hardnesses in excess of diamond pyramid hardness No. 500 in the heat-affected zone. Dearden and O'Neill, in accepting the limit of diamond pyramid hardness No. 350 as a working basis, made the reservation that "some martensites are tougher than others," and a recent development has substituted ductility for hardness as a measure of weldability. This principle is developed in the systems recently evolved by Doan and Hess for predicting the welding conditions required to produce crack-free welds in given steels. Both systems are based on the fundamental premise that the mechanical properties of the heat-affected material of a given steel are entirely determined by the cooling rate in the critical range of transformation of the austenite.

The principle of relating welding conditions—including "joint geometry"—through the cooling rates so produced, and the knowledge of the transformation characteristics of the steel concerned, to the structure and ductility of the heat-affected zone produced, is now widely accepted. It gives very satisfactory results over a wide range of low-alloy steel compositions. All these methods of estimating weldability, however, may lead to error in the presence of disturbing factors, such as the absorption of hydrogen, which is discussed later.

It will be seen from the foregoing outline of the factors involved in the welding of low-alloy steels that the prevention of cracking in these steels depends upon the control of the metallurgical structure of the heat-affected zone, in which the formation of martensite must be prevented as far as possible. As, however,

* Paper entitled "Factors Influencing the Weldability of High-Tensile Alloy Steels, and a New Weld-Cracking Test," presented to the Institution of Mechanical Engineers for written discussion. Abridged.

WELD-CRACKING TEST JIG FOR HIGH-TENSILE STEELS.

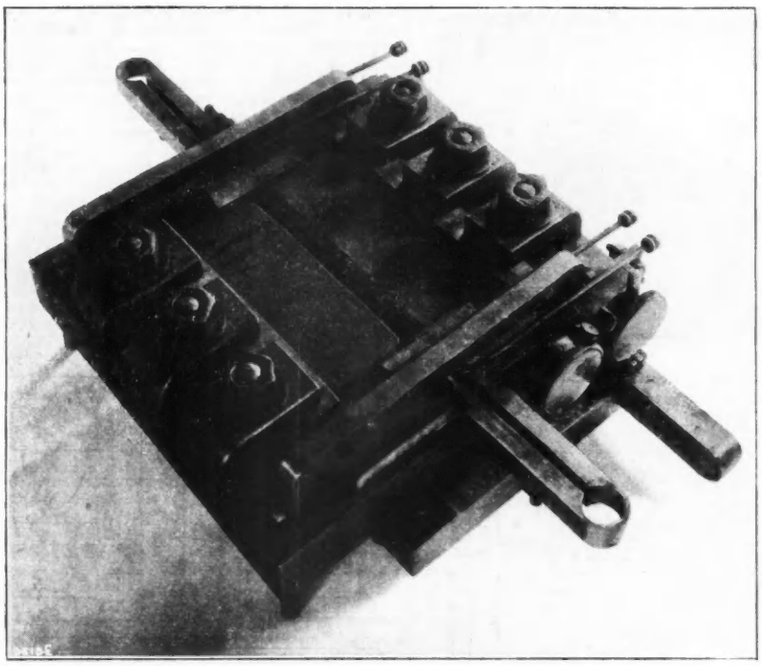


FIG. 6. MOND WELD-CRACKING TEST JIG.

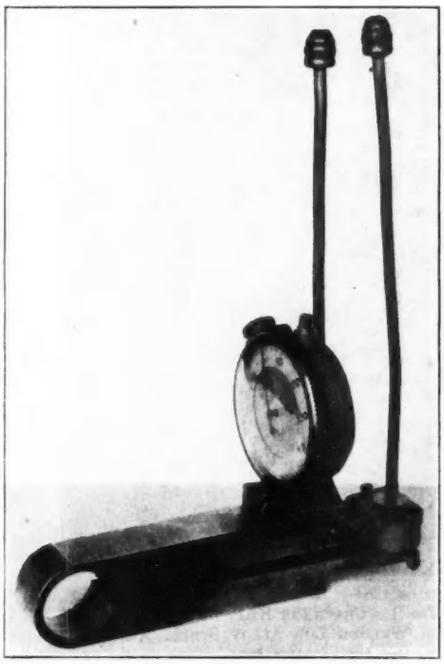


FIG. 7. COMPRESSION CYLINDER ATTACHMENT.

the carbon and alloy contents of a steel are progressively increased, with consequent increase in hardenability, it eventually becomes impossible to prevent the formation of martensite by any ordinary welding conditions, and it becomes necessary to resort to treatments such as pre-heating and post-heating of the joint. The exact effect of these treatments depends upon the circumstances. In so far as they reduce the rate of cooling after welding, they may, with a suitable steel, induce transformation to occur above the martensite point, with the consequent formation of a tougher product. In the case of a steel with a very low critical cooling rate, however, the effect will be to temper and toughen the martensite formed.

There is, however, evidence that the welding of steels in the air-hardening range, where the heat-affected zones are always substantially fully martensitic, involves factors which are not apparent in the welding of low-alloy steels. For example, a steel which cannot be welded with ordinary ferritic electrodes can often be welded quite satisfactorily with austenitic electrodes of the 18/8 chromium-nickel type, and until recently the higher alloy steels could be welded only in this way. There is no significant difference in the microstructure or hardness of the heat-affected zones of a deep-hardening steel welded with ferritic and austenitic electrodes respectively, and the difference in behaviour caused by these two types of electrode must be due to factors which are not so apparent in the case of the lower alloy and less hardenable steels. In other words, although the degree of hardening produced is the principal operative factor in the welding of low-alloy steels, other factors are also involved and become increasingly important in cases where mainly martensitic heat-affected zones are produced.

The ability of austenitic electrodes to produce uncracked welds in steels too hardenable to be welded by ferritic electrodes was commonly explained in terms of the different properties of the two types of weld deposit: it was argued that, owing to its lower yield point, the austenitic weld metal allowed sufficient yield to prevent cracking. Examination of the actual mechanical properties of representative deposits, however, shows that the differences are not sufficiently great to be likely to account for such a marked difference in behaviour, and in any case it is possible that since the stresses in a weld are tri-axial, any effect of ductility in the weld metal may be minimised. As will be seen later, it has been demonstrated experimentally that austenitic weld metal does not reduce the stress in a weld and the explanation has thus to be sought elsewhere.

A given steel, furthermore, can exhibit markedly differing weldabilities when welded with different types of austenitic electrodes, under conditions producing identical microstructures and hardnesses in the heat-affected zones. It is therefore clear that, in the welding of high-tensile steel, the properties of the martensite, undoubtedly important, are not the only factor concerned, and that a further factor, apparently introduced by the electrode, is also involved. The study of the effects of the various factors in welding, and of weld cracking problems in general, is carried out to a large extent by means of so-called "weld cracking tests," and the work, described later, was carried out with the aid of a development of one of these tests.

Fig. 8.

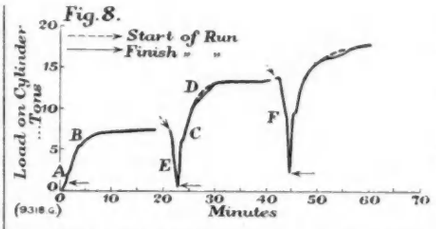
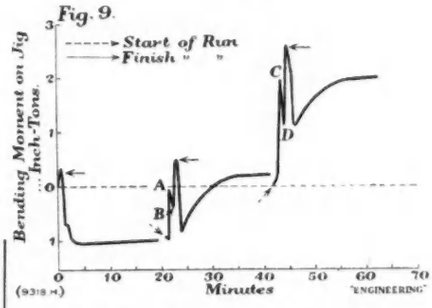


Fig. 9.



A weld cracking test is one in which an experimental weld is prepared under controlled conditions of restraint, and may be for the purpose of testing either the parent steel or the electrode. A considerable number and variety of these tests have been devised from time to time. Most of these tests consist of some form of butt or fillet weld in which the restraint is provided either by the stiffness of the test pieces themselves, by means of a restraining jig, or by a combination of both. Weld cracking tests can be used in several ways. Under fixed welding conditions and degree of restraint, they can be used to place a series of steels in an order of merit according to the observed amount of cracking, if any, occurring in each case. By including a steel of known weldability in the series, the probable performance of the experimental steels can be predicted in terms of that standard. Alternatively, by using a steel of known weldability with a given degree of restraint, the tests can be used to study the effects of variations in electrode materials and in welding conditions and technique.

One of the best known and most generally useful of these tests is the Reeve tied fillet-weld test in which two superimposed plates measuring 10 in. by 7 in. and 6 in. square, respectively, are clamped to a heavy rigid baseplate by means of four 1-in. diameter bolts. The rigidity of the set-up is increased by three "anchor" fillet welds deposited along three sides of the 6-in. square plate. When these are cold, the fourth fillet, which constitutes the test weld, is deposited under chosen welding conditions. When the test run has reached room temperature, three cross-sections are cut from it, and examined for cracks, microstructure, and hardness. A typical section from a Reeve test, showing a crack and the positions of hardness indentations is shown in Fig. 2, on page 573.

The severity of the test is increased by increasing the thickness of the test plates, this having the combined effect of stiffening the set-up, and increasing the quench effect on the heat-affected material adjacent to the weld. The severity of the test can also be varied by varying the size of fillet deposited; this has been demonstrated experimentally by many investigators and it also follows from theoretical considerations, since a larger fillet, with its greater heat input, will result in a slower cooling rate after welding, with the results already discussed. By combining the variables of plate thickness and electrode size a considerable range of test conditions can be produced. The test has thus been found particularly useful for assessing the weldability of newly developed steels, and, to a lesser extent, the performance of new electrodes.

A rather different form of restrained weld test which is of interest is the ring test. In this test a circular patch is cut from the centre of a square plate, by machining a V-shaped groove on both sides to form a double "V" circular groove between the two parts. The circular patch is then welded back into position with welds on both sides. This test, which has been described by Moore and Tremlett, has been found to be particularly suitable for revealing hot crack sensitivity in electrodes and is now used more for this purpose than for producing cold cracks in the parent plate. From the point of view of their usefulness for research purposes, the tests referred to above have a common limitation, which is that they are essentially qualitative and not quantitative in character. They will place a series of steels in an order of merit, but they will not indicate how much one is better than another;

neither do they give any measure of the stresses or forces involved in each case, or any indication of the onset and course of the cracking. Some investigators have developed modified tied butt-weld tests designed to meet these shortcomings.

In connection with programmes of research aimed at exploring the factors affecting the stress levels reached in welds and their relationship to cracking behaviour, and, in particular, to examine the difference in performance of austenitic and ferritic electrodes, the Development and Research Department of the Mond Nickel Company, Limited, developed a quantitative type of weld cracking test with the general object of obtaining more informative results than were previously possible. This test, which is of the tied butt-weld type, embodies two important new features compared with the previous tests described. In the first place, it measures the stress across the weld directly, instead of measuring stresses arising out of the thermal expansion and contraction of the test plates. Secondly, it takes into account the fact that, when a pair of plates are butt-welded, a couple at right-angles to their plane is superimposed on the main stress pulling the plates together in their own plane. This couple is due to the asymmetrical deposition of weld metal with respect to the neutral axis of the plates in their own plane. Its effect is commonly seen in the upward movement of the outer edges of plates butt-welded without restraint.

In this test, the test plates are mounted in a calibrated jig which restrains their movement due to welding stresses in two directions, and which, by its own deflection, provides a measure of the forces exerted on it by the welded test plates. This apparatus has been found to produce satisfactorily reproducible records showing the fluctuations in stress during and after welding, and enabling the onset and course of cracking to be followed closely. The test conditions, furthermore, are closely controllable. As will be seen later, this test has enabled a number of important facts, not previously apparent, to be established.

The test employs test plates of the type shown in Fig. 3, on page 573. They are mounted in the jig, illustrated in Figs. 4 and 5, on page 573, and in Fig. 6, opposite. This jig restrains them from bending in a general direction perpendicular to their own plane when welded. Fig. 5 is a plan view and Fig. 4 an end elevation of the jig. Fig. 6 shows the jig with test plates in position. The test plates are held down on the jig by means of six clamps at the outside edges and by "T" bolts at the centre. The jig is made of high tensile nickel-chromium-molybdenum steel heat treated to a high yield strength level and is designed to record, by means of the heavy lever *a* and the dial gauge *b*, Figs. 4 and 5, the amount of bowing caused by the test plates when welded. Vibrations in the lever *a* are reduced to a minimum by means of the spring caliper *c*. By calibrating the stiffness of the jig in a testing machine, this can be interpreted into terms of the couple or bending moment, in inch-tons, exerted by the test plates on the jig as a result of welding. It will be appreciated that this calibration is correct only prior to the welding of the test plates. Thereafter it is only approximate on account of the stiffening effect of the welded plates.

The test plates are restrained from moving in their own plane by means of two steel cylinders placed between them on each side of the "V." For this purpose the abutting edges of the test plates are cut away as indicated in Fig. 3. The compression of these cylinders provides a direct measure of the main force across the weld. The cylinders are made of 2¼ per cent. nickel-chromium steel containing 1 per cent. carbon, oil quenched and tempered to an equivalent compressional yield strength of about 200 tons per square inch. By calibration in a testing machine, the compression of these cylinders by the test plates as a result of welding can be converted into load in tons. The compression of the cylinders is measured with the aid of the attachment shown in Fig. 7, opposite, which consists of a dial gauge mounted in a spring caliper. The compression cylinder is kept cool during operation by means of a water jacket. In setting up the test, any slack between the test plates and the compression cylinders prior to welding is taken up by the clamps *d* and *e*, Figs. 4 and 5.

The rigidity of both the jig and the compression cylinders was arranged to give a reasonably large reading on the gauges, while permitting the minimum relief of stress on the test plates by their movement. Heating of the "waist" of the jig, beneath the weld, by radiation is prevented by the asbestos packing *f*, Fig. 4. The rise in temperature of the heavy jig by conduction through the test plates is never more than 15 to 20 deg. C. (59 to 68 deg. F.). Calculations of the maximum transverse stress across the weld, based on the loads on the cylinders and jig, must be considered with reserve on account of the necessity of making two important assumptions, namely, that the stress distributions along the length of the weld and through its thickness are linear.

The blanks for the test plates are gas cut from the parent plate and then (if necessary) tempered at about 600 deg. C. (1,100 deg. F.) to render them readily machinable. The machining and heat treatment operations are then as follows: (1) shaping of sides and ends to provide rectangular plates 11¼ in. by 3¾ in.; (2) surface grinding of top and bottom surfaces; (3) grinding of bevel along one 11¼-in. side of each plate to provide 60 deg. (inclusive) "V"; (4) shaping of recesses at both ends of plate to receive compression cylinders, leaving 6-in. long bevel symmetrically at centre of long edge; depth of recesses arranged to give (at this stage) a nil root gap, with cylinders in position; (5) heat treatment of plates by oil quenching and tempering to give required Brinell hardness; (6) final surface grinding of plates to remove any distortion due to heat treatment; and (7) final grinding of 6-in. long bevels to provide root gap of required width. Before finally mounting on to the test jig, the edges of the plates are smoothed with a file and emery paper to remove any small burrs or machining flashes.

The principal consideration affecting the assembly is that of avoiding friction between the test plates and the jig. General consideration of the system of forces on the test plates leads to the conclusion that, ideally, there should be no friction between them and the jig. This is achieved as far as possible by surface grinding the plates as detailed above, using a film of high-pressure grease between the jig and test plates and by tightening the clamps sufficiently only to take up all possible slack. Care is also taken to ensure the correct location of the compression cylinders, and the taking up of all slack between them and the butts on the test plates immediately prior to welding. This is done by accurate measurement and the use of the clamps *d*, *e* (Fig. 5), respectively.

Welding is commenced after the current and open-circuit voltage values have been set and the water turned on in the compression cylinder cooling jackets. Two observers record the readings of the dial gauges against a stop watch, zero time being the striking of the arc. Readings are taken at 5-second intervals during marked fluctuations of stress and less frequently according to circumstances. A standard interval of 20 minutes is allowed between runs. Slag is chipped away as soon as the gauge needles become reasonably steady, which is usually after about 10 minutes, and chipping has very little, if any, effect upon the readings. In cases where one electrode is insufficient to complete a run, the end of the first part of the run is chipped free from slag and the run completed with a second electrode with the minimum of delay. The effect of this on the curves of load versus time will be seen later. After completion of the weld, the test plates are normally left on the jig for three days, or until complete cracking occurs, readings being taken at suitable intervals.

The cooling rates of the welds are measured (when desired) by means of a platinum and platinum-rhodium thermocouple flash-welded into a ⅛-in. diameter hole drilled in one plate from the root side and extending to within $\frac{3}{16}$ in. of the top surface, and to within approximately $\frac{1}{16}$ in. of the edge of the bevel. The flash welding is carried out by making the plate one electrode and the thermocouple, stiffened and insulated by a twin-bore sheath of recrystallised alumina, the other electrode, and then passing an alternating current at 40 volts through a 10-ampere fuse in series with the couple. The temperatures are recorded photographically by directing a spot of light from the galvanometer mirror on to a sensitised paper, the time being recorded by interrupting the spot of light between the galvanometer mirror and the photographic paper at regular intervals. This is done by means of a rotating disc with two segments removed. This disc is driven by a synchronous motor and with the aid of suitable gearing, is made to rotate once in 40 seconds or, in other words, to make and break the spot of light at 10-second intervals. This interval was found by experiment to be the most suitable to make the time intervals in the temperature line large enough to be distinguishable at the slow cooling rates occurring in the region of 180 deg. C. (356 deg. F.), but at the same time small enough to give a reasonably sensitive cooling curve.

The arc current and closed-circuit voltage are normally measured on the ammeter and voltmeter, fitted to the welding set, but in cases where particular interest is attached to the exact total energy used in a weld, check tests are carried out using copper voltametric cells. From Fig. 8, opposite, the general form of the load versus time curves will be seen. In these curves which relate to the compression of cylinders, the load in the first run rises fairly steadily to a maximum, which is maintained (unless cracking occurs) until the start of the next run. At the start of the second run, the load decreases sharply until the run has been completed, when it almost immediately rises again to a new maximum which is maintained until the next run is put down. The third run causes similar behaviour of the load, except that a still higher maximum is reached, and so on. The fall in load which takes place while a run is being deposited is, of course, due to the relaxation of stress provided by the thermal expansion. In addition to this general form, however, the curves show a number of arrests. The first run always shows one fairly well defined arrest (point A, Fig. 8) and sometimes a second, usually less well defined, as at point B. An arrest corresponding to that at A was also observed by Hanson and his associates, who showed that it was probably due mainly to relaxation afforded by the martensite transformation. The subsequent runs each show an arrest corresponding to the first one on the first run in the rising curve after completion of the run, and sometimes some evidence of a second one (points C and D). In runs where it has been necessary to use a second electrode, the brief interval causes a halt in the fall of the load until the recommencement of welding, when the load decreases again. Arrests due to changing electrodes can be seen at E and F.

The load curves for the bowing of the jig, shown in Fig. 9, are of the following form: in the first run the bending moment, after an initial rise to a small "positive" value, changes rapidly to a substantially constant "negative" value, which is maintained until the start of the second run. In the second run, the negative bending moment falls off sharply, and usually reaches a small positive value before again rising to another negative value somewhat less than that reached in the first run. When this value has been reached, a third but less sharp reversal of stress takes place, which also generally reaches a positive value. The third run causes similar reversals of stress except that the bending moments are now almost entirely positive, while in any subsequent runs the curves maintain their characteristic appearance, although increasingly displaced in the positive direction. The changing of an electrode causes a sharp temporary reversal of bending moment, as shown in Fig. 9 (A-B and C-D). This reversal starts the moment the first electrode is finished, and ceases when the new arc is struck.

When cracking occurs, its onset is indicated by a falling off in the bending moment on the jig, which may occur some time before a crack becomes visible. If the plates crack completely in a very short space of time, the curve drops almost vertically to zero. If, however, the cracking is progressive, the curve drops more gradually, and many at a later stage reach a negative value. If the cracking then becomes complete, the load returns to zero. The load on the compression cylinders does not fall appreciably until cracking is nearly complete.

(To be continued.)

CATALOGUES.

Electronic Control of Electric Motors.—The application of electronic methods to the control of electric motors is described in a pamphlet recently published by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

Heated Towel Rails.—Messrs. Newman, Hender and Company, Limited, Woodchester, Gloucestershire, have sent us a copy of a leaflet on the heated towel rails which they manufacture. There are several different designs, suitable for floor, wall, or floor-and-wall fixing.

Transformers.—Details of the oil-immersed power transformers, which are manufactured by them in capacities from 5 kVA up to the largest units for extra-high voltages, are given in a well-illustrated publication issued by Messrs. C. A. Parsons and Company, Limited, Heaton Works, Newcastle-on-Tyne, 6.

Grinding Wheels.—We have received a copy of the second edition of a book on grinding which is published, at 12*s.* 6*d.* net, by Messrs. A. A. Jones and Shipman, Limited, Narborough Road South, Leicester. The book is divided into three sections, dealing with the practice of grinding, the selection of a suitable wheel, and the correction of defects in grinding.

Electrical Testing Instruments for Factories.—Aeronautical and General Instruments, Limited, Purley Way, Croydon, have issued pamphlets dealing with the test equipment they have designed to minimise the possibility of accidents due to faulty electric tools. This is rapid in operation, so that tests can be included in the regular maintenance routine.

Fittings for Mercury and Mercury-Fluorescent Lamps.—Philips Electrical, Limited, Century House, Shaftesbury-avenue, London, W.C.2, have issued a leaflet giving detailed information of the industrial fittings which they are making of mercury and mercury-fluorescent lamps. These include a pattern in which the reflector can be removed without disturbing the lamp or wiring.

Hobbing Machines.—Messrs. David Brown Machine Tools, Limited, Britannia Works, Sherborne-street, Manchester, 3, make three sizes of moving-table type gear-hobbing machines, which are described in a catalogue we have received from them. Spur gears, helical gears and splines can be cut, using standard equipment; worm wheels can be cut with parallel hobs, and tangential hob slides are available for cutting worm wheels with taper hobs.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

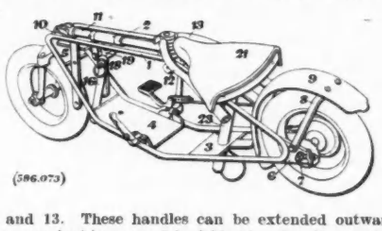
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MOTOR VEHICLES.

596,073. Motor Bicycle. J. R. V. Dolphin, of Welwyn, Hertfordshire. (3 *Figs.*) July 17, 1945.—This invention relates to motor bicycles, its object being to provide a light-weight machine which will be of strong and robust construction and which, when not in use, can be packed into a small compass so that it may be easily transported from place to place or used by airborne or parachute troops. The frame consists of two closed loops 1 and 2 formed of tubular material, parallel to one another and united by rigid brackets 3, 4 and 5, additional plates or brackets being provided at suitable positions if required. Each loop has the upper and lower portions substantially parallel to one another for a part of their length and terminate in angular portions as shown. The rear ends of the loops have brackets 6 attached to them carrying the rear-wheel axle 7 and the stays 8 for the rear mudguard 9, while the front portions of the loops are welded to the upper part 10 of the front-wheel fork. Pivoted to the fork member 10 is a pillar 11 carrying the handles



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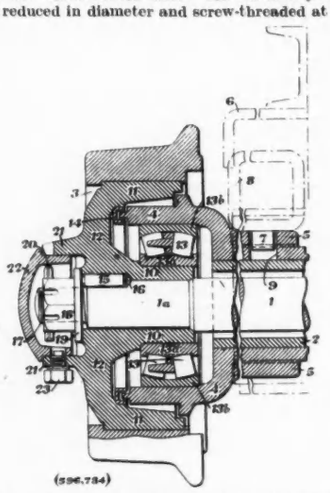
12 and 13. These handles can be extended outwards when required in use and be folded in when the machine is to be collapsed. The handles can be locked in the required position. Pivoted to the pillar 11 is a stay 16 which is used to support the pillar 11 in its extended position, the lower end of the stay 16 having a hole which co-operates with a spring-loaded trunnion locating pin 18 munted in a bracket 19, secured between the frame members 1 and 2, this pin being arranged to click into the hole when the pillar is raised so as to secure the stay in position. The fuel tank (not shown) is of the pannier form, consisting of two parts secured to the forward part of the frame. The seat 21 is carried upon a pillar which is telescoped into a tube 23 within the frame. Thus, when both the seat pillar and the handles are collapsed and the latter are swung inwards, the overall height and width of the machine is only that of the height and width of the frame. The engine, carburettor and other accessories (not shown) occupy the space over the bracket 4. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

596,734. Wheel Mounting for Railway Vehicles. Robert Hudson, Limited, and W. S. Hudson, both of Leeds. (5 *Figs.*) August 1, 1945.—This invention is a method of mounting wheels for railway vehicles that minimises end thrust and facilitates dismounting. An axle 1 is rotatably mounted in a solid-drawn steel sleeve 2, an end 1*a* of the axle projecting beyond the end of the sleeve 2 to receive a wheel 3. A cast-steel cylindrical housing 4 is secured by a reduced inner end 5 to the sleeve 2, which projects but little beyond a frame member 6 of the vehicle. The sleeve 2 and housing 4 are fixed relatively to the vehicle frame by a spigot 7 on a spring shackle 8 engaging in an aperture 9 in the reduced end 5. The housing 4 has an open outer end within which extends axially a cylindrical hub 10 of the wheel 3 fitting on the axle end 1*a*, the wheel having a flanged rim 11 that surrounds the housing and is connected by an integral disc 12 to the outer end of the hub 10. The inner end of the latter carries the inner race 13*a* of a double thrust roller bearing 13 to take both the radial load and the end thrust on the wheel, the outer race 13*b* of the bearing being mounted within the cylindrical housing 4. The races 13*a* and 13*b* are located entirely outside the plane containing the inner edge of the rim of the wheel 3. The outer edge of the housing 4 is reduced in thickness and carries an annulus 14 of synthetic rubber which forms an oil seal outside the bearing 13 for the space between the disc 12 and the housing 4. Retaining pins 15, driven into holes 16 parallel with the axis of the hub 10, partly in the latter and partly in the axle end 1*a*, prevent rotation of the wheel on the axle. The extremity of the axle is reduced in diameter and screw-threaded at 17 to



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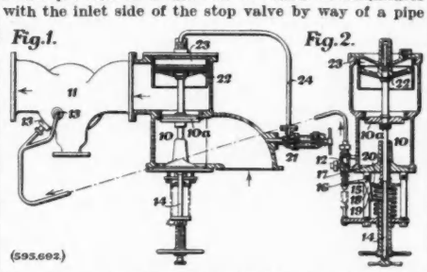
receive a nut 18 which urges a washer 19 against the outer face of the hub 10. A split pin 20 locks the nut 18 in position on the axle. The disc portion 12 of the wheel 3 is formed with an annular flange 21 to receive a hub cap 22, which is held in position by a screw 23 extending into a wall of the cap through a threaded hole in the flange 21. (*Sealed.*)

STEAM ENGINES, BOILERS, ETC.

595,692. Steam Desuperheater. Cockburn\, Limited, J. Rodger and T. Grant, all of Cardonald, Glasgow. (3 *Figs.*) April 2, 1945.—This invention is a combined self-acting steam stop valve and a steam desuperheater into which exhaust or other steam is admitted under the control of the stop valve. The steam installation shown in Figs. 1 and 2 incorporates a self-acting steam stop valve 10 and a steam desuperheater 11 into which exhaust or other steam is admitted under the control of the stop valve 10. The stop valve 10 is piston-operated and spring-loaded and is arranged to open and close in response to changes of pressure on its inlet side. The upper face of the piston 22 of the stop valve is exposed to steam pressure in a chamber 23 which communicates with the inlet side of the stop valve by way of a pipe

Fig.1. *Fig.2.*



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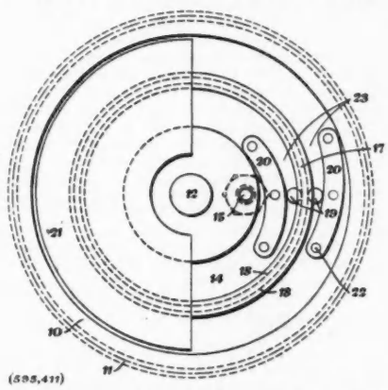
24 and an external control valve 21. A water-control valve 12 is connected with the stop valve 10 so that the opening and closing movements of the valve 12 are functions, respectively, of the opening and closing movements of the stop valve. The valve 12 controls the supply of desuperheating water to the spray nozzles 13 of the desuperheater 11 and operates so that the rate of flow of water to the desuperheater is always proportional to the rate of flow of steam to the desuperheater. The valve 12 is attached to the casing of the stop valve 10 and operated from the spindle 14 of the stop valve proper through the medium of a spring-urged bell-crank lever. One arm 15 of this lever is connected at 16 to the spindle 17 of the valve 12 and the other arm 18 presents an inclined cam surface 19 which is tracked by a follower roller 20 that participates in the axial travel of the spindle 14 of the stop valve. The shape and the inclination of the cam surface 19 are such as to give the requisite steam-water flow characteristic. (*Sealed.*)

TEXTILE MACHINERY.

595,411. Drafting-Roller Gearing. Casablancas High Draft Company, Limited, and J. Noguera, both of Manchester. (5 *Figs.*) November 13, 1944.—This invention relates to the gearing associated with the drafting rollers of drafting mechanism for textile fibres. Its object is to prevent the back roller wheel from springing backwards when the change shaft pinion is disengaged for the purpose of changing the gearing ratio or draft. The back roller wheel consists of a shell 10 having teeth 11 on its outer periphery, the shell being freely mounted on the driving shaft 12, which is supported in a carrier bracket. A driving plate 14 of hollow form is attached to the driving shaft 12 and is located within the shell 10 to which it is secured by means of a screw 15. The driving plate 14 terminates short of the inner periphery of the shell and is provided with a peripheral flange 17, which is channelled at 18 on either face to provide guiding surfaces for steel balls 19. Segments 20 are attached to a plate 21 by means of screws 22, the plate 21 being in turn attached



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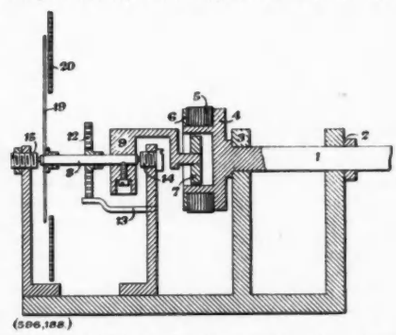
to the carrier bracket. The segments 20 are disposed on each side of the peripheral flange 17 on the driving plate in such a way that channels 23 are formed between the segments and the peripheral flange which are divergent in the direction of rotation of the wheel (counter-clockwise as shown). A steel ball 19 is located in each of these channels 23 and the balls are guided by engagement with the channels 18 in the peripheral flange. The segments 20 are made of hardened steel and by forming the back roller wheel with the driving plate as above described, it is possible to make the wheel shell of cast iron in the usual way while making the driving plate with the peripheral bearing flange of steel. (*Sealed.*)

MISCELLANEOUS.

596,188. Magnetic Speedometer. Evershed and Vignoles, Limited, and J. C. Needham, both of Chiswick, London. (2 *Figs.*) July 24, 1945.—This invention is a magnetic speedometer of a light, portable and well damped type. An input spindle 1, which is driven by the machine the speed of rotation of which is to be measured, is mounted in two bearing brackets 2 and 3, and carries on its inner end a copper drum 4. This copper drum has mounted on its outside surface a magnetic yoke 5, consisting of a set of flat annular laminations. The laminations are of the low-hysteresis material known Permalloy. The magnetic yoke 5 is held in position by the end ring 6. The copper drum 4 is bored centrally on its inner face to receive, with working clearance, a disc magnet 7 made of an alloy



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steel having a high coercive force, such as those known as Alnico or Alni, and is magnetised along a diameter. The magnet 7 is mounted coaxially with the magnet spindle 8 by a shaped bracket 9. The torque transmitted from the drum 4 to the magnet 7 and the magnet spindle 8 is balanced by a control spring 12, which is connected at its inner end to the magnet spindle 8 and at its outer end to a fixed anchor 13. The magnet spindle is reduced at each end to fit into two cone bearings 14 and 15. The magnet spindle 8 has a radial pointer 19, which moves over a suitably graduated scale 20. If required, the position of rest of the pointer 19 can be arranged to be at the centre of the graduated scale 20 and the spiral spring 12 arranged to provide a balancing torque in either direction of rotation of the magnet spindle 8, thus providing a centre-zero instrument. (*Sealed.*)